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Wastes generated were characterized and quantified in typical hog slaughtering operations both before and after modifications were made to reduce wastewater volume and strength and to increase by-product recovery. The research was carried out in the Oscar Mayer plants at Madison, Wisconsin, Beardstown, Illinois, and Davenport, Iowa.

In the Madison plant, about two thirds of the flow and 80% of the BOD_5 were discharged during the production shift; the balance was from cleanup. The average work day for production was 7.79 hr, during which the Live Weight Killed (LWK) averaged 1.4 million pounds. The flow resulting from this operation was 520,000 gal/day or 362.7 gal/1000 lb LWK. The BOD_5 load was 6,100 lb/day, or 4.26 lb BOD_5/1000 lb LWK.

Process modifications reduced the flow by 41%, the BOD_5 by 63%, and the suspended solids by 63%. Most process modifications cost only a few hundred dollars; the most expensive change cost $12,000. Every modification will pay for itself within 1 or 2 years. Often the savings in water alone justifies a modification, and savings in waste treatment and surcharges are a bonus. Individual process modifications annually saved from $200 for simply turning off a valve up to $129,000 for modifying the hasher washer to recover more scrap for rendering.

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FOREWORD

When energy and material resources are extracted, processed, converted, and used the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory-Cincinnati (IERL-Ci) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

The report characterizes wastes generated by hog slaughtering operations and demonstrates in-plant reductions of wastewater volume and strength. The information will enable managers and designers of hog slaughtering plants to make major reductions in waste discharges. For further information on the subject the Food and Wood Products Branch at the Corvallis Field Station should be contacted.

David G. Stephan
Director
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ABSTRACT

The objective of this project was to characterize and quantify wastes generated in a typical hog slaughtering operation both before and after modifications were made to reduce wastewater volume and strength and to increase by-product recovery. The research was carried out in the Oscar Mayer plants at Madison, Wisconsin, in Beardstown, Illinois, and in Davenport, Iowa.

In the Madison plant, about two thirds of the flow and 80% of the BOD_5 were discharged during the production shift; the balance was from cleanup. Total solids, suspended solids, volatile solids fractions, COD, total Kjeldahl nitrogen, total organic carbon, and grease were also measured. Each of these wastewater parameters was discharged in proportion to BOD_5.

The average work day for production was 7.78 hr, during which an average of 1.4 million pounds live weight of hogs were slaughtered (652,340 kg/day). The flow resulting from this operation was 520,000 gal/day (22.81 l/s), or 362.7 gal/1000 lb live weight killed (LWK). The BOD_5 load was 6,100 lb/day (2769 kg/day), or 4.26 lb BOD_5/1000 lb LWK. This figure represents about 10% of the total flow from the Madison plant, which is a full-range packinghouse, and about 25% to 30% of the total BOD load.

Process modifications were made that reduced the flow by 41%, the BOD_5 by 63%, and the suspended solids by 63%. Some changes were costless, or nearly so; the most expensive change cost $12,000. Most process modifications cost only a few hundred dollars. Every modification will pay for itself within 1 or 2 years. Often the savings in water alone justifies a modification, and savings in waste treatment and surcharges are a bonus. Individual process modifications saved from $280 for simply turning off a valve up to $129,000 for modifying the hasher washer to recover more scrap for rendering. These are annual savings. The total present value of savings due to all modifications (over 5 years at 10% interest) is more than a half million dollars.

Details of the in-plant survey methods used, the data obtained, the process modifications, and the economic analyses for each modification are given in this report.

This report was submitted in fulfillment of Grant No. 802833 by the University of Wisconsin and Oscar Mayer and Co. under the sponsorship of the U.S. Environmental Protection Agency. The report covers the period 3/1/74 to 2/27/76, and work was completed as of 4/27/76.

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Dr. John M. Harkin, Soil Science and Water Resources Center, University of Wisconsin-Madison, established and supervised the laboratory support program for the project. John Straughn worked as Laboratory Specialist throughout the project.

The cooperation and assistance of many individuals in General Engineering and the Production Departments of Oscar Mayer & Co. are acknowledged.

Project administration and secretarial help was provided by the Water Resources Center, University of Wisconsin-Madison.

SECTION I

INTRODUCTION

The objective of this project was to characterize and quantify wastes generated in a typical hog slaughtering operation both before and after modifications were made to reduce wastewater volume and strength and to increase by-product recovery.

One goal of this project was to see what could be reasonably accomplished in a typical, large hog slaughtering operation without major alterations to the plant, and with little or no hindrance to the productive output. This need to reduce in-plant waste while maintaining the usual production rate and quality required the cooperation of the operating personnel involved and the backing of management. To this end, project personnel diligently kept line supervision informed, and meetings were held to obtain the opinions and recommendations of the people involved in any proposed change. A second goal was to make the subsequent in-plant control easier and less costly.

Special attention was given to locations on the kill floor with greatest potential for pollution load reduction through changes in work procedures, equipment, and process redesign. Care was taken to insure that these changes did not interfere with the rate of production, the quality of the product, or the health and safety of the workers.

Until recently, almost all emphasis in handling meat industry wastewaters was directed toward end-of-pipe treatment. However, it has been apparent to those familiar with the industry that the potential exists for achievement of significant wasteload reductions through in-plant measures. These in-plant measures can be designed into a new plant, but they present numerous implementation problems in existing facilities.

MOTIVATION FOR THE STUDY

The enactment of the Federal Water Pollution Control Act Amendments of 1972 has provided added emphasis on in-plant measures as "Best Available Technology Economically Available" required to be met by July 1, 1983. Effluent guidelines and standards promulgated by the U.S. Environmental Protection Agency envision extensive in-plant control of pollutional losses.

The recently published Red Meat Industry Development Document (1) makes reference to water control systems and procedures to reduce water use by about 50%. Hog slaughtering operators should be interested in the results of this study in that approximately 50% of their facilities are direct dischargers to public waters, while most of the remainder are subject to the public facility user charge and industrial cost recovery provisions of the 1972 Act (Public Law 92-500).

The meat industry was identified in the 1972 Act as one of 27 industries requiring standards of performance for new sources (Sec. 306). The listed industries, including "meat product and rendering processing," have also been covered by effluent guidelines and standards issued by the EPA. The Federal Register, on February 28, 1974 published "Best Practicable Control Technology Currently Available" (July 1, 1977) and "Best Available Technology Economically Available" (July 1, 1983) effluent requirements for the red meat industry. These are the Federal limits which are applicable to effluents from existing hog slaughtering operations which are discharged to public waters.

Effluent requirements for discharge to Publicly Owned Treatment Works (POTW) are not stringent, but the discharge is subject to Federally defined user charge and industrial cost recovery provisions. POTW user charges are escalating rapidly, and the industrial cost recovery requirement is spreading so that it will be in effect at almost all POTW by 1983.

STATUS OF THE MEAT INDUSTRY

The meat industry is America's largest food industry and is included for statistical purposes in the food products category classification. The 1974 employment data for comparison with the entire food industry and with all manufacturing is shown in Table 1. In 1975, a nationwide shortage of hogs resulted in the largest year-to-year drop in hog slaughter in 30 years. Preliminary figures for 1975 hog slaughter are presented in Table 2.

TABLE 1. EMPLOYMENT STATISTICS IN 1974 (1)

Industry	Total employees	% of all manufacturing
Meat packing (SIC2011)	170,200	0.9
Meat processing (SIC2013)	62,100	0.3
	232,300	1.2
All food	1,720,800	8.6
All manufacturing	20,016,000	100.0

Table 7. SLAUGHTER OF HOGS IN 1975 (7)

Slaughtering site	Head killed	% in 1974
Federal inspection	64,927,700	84
State inspection	3,762,000	86
Farm slaughter, est.	810,000	80
TOTAL	69,499,700	

The reduced supply of hogs adversely affected the industry as fixed costs associated with slaughtering facility over-capacity eroded profitability and highlighted the need for cost saving conservation measures. Much of the water use within a plant is fixed since the water use per 1000/lb LWK increased significantly during this time.

SUMMARY

The meat industry is large and comprises hog slaughtering plants of every age and various descriptions. There is legal and economic pressure for all plants to study in-plant reduction methods.

SECTION II

SUMMARY

The quantity of wastewater issuing from the hog slaughtering floor and the quantities of pollutants (BOD, COD, Kjeldahl nitrogen, suspended solids, etc.) carried by this wastewater has been measured for both the production shift and the cleanup shift. Several process modifications have been made to reduce flow and the pollution load. The cost to make the changes ranged from zero to $12,000; most cost only a few hundred dollars. Savings ran from $280 annually for turning off a valve to $128,944 annually for modifying the hasher-washer to recover more scrap for rendering while simultaneously reducing the pollution load discharged. Even small and simple modifications resulted in annual savings of several thousand dollars/yr. Often the savings in water alone more than paid for the modification with savings due to pollution load reduction being a tidy bonus. No installed change failed to more than pay for itself. In-plant modifications are cost-effective, sometimes astonishingly so.

It is hoped that the results of this study will make plant management more receptive to making modifications, even when this requires reordering priorities for assignment of mechanics and plumbers to do the work.

The Madison plant processes beef in addition to hogs, processes the meat into packaged products, manufactures spices and plastic packaging materials, and incorporates some other operations. The hog slaughtering operation represented about 520,000 gal./day wastewater flow (22.8 l/sec) and 6,100 BOD_5 lb/day (2,772 kg BOD_5/day). This is about 10% of the flow and 25 to 30% of the BOD from the entire Madison plant.

The changes described in the report reduce the flow to about 310,000 gal./day (1,173,350 l/day) and the BOD load to 2,250 lb/day (1,023 kg/day). This BOD reduction is a noticeable fraction of the total plant discharge. The suspended solids discharge was reduced from 6,100 lb/day to about 2,300 lb/day (1,045 kg/day).

Two-thirds of the flow was discharged during the production shift. The three largest water users in Madison for production are the dehairing machine, 70.5 gal./1000 lb LWK; the stomach washer, 48.5 gal./1000 lb LWK; and the process areas that contribute to sluice material to the hasher-washer, 53.2 gal./1000 lb LWK.

BOD load comes primarily from the hasher-washer, 2.707 lb/1000 lb LWK out of a total for production and cleanup of 4.266 lb/1000 lb LWK. The stomach washer discharges 0.549 lb/1000 lb LWK and the next largest contributors are the dehairing machine (0.661 lb/1000 lb LWK) and the 330 hog/hr kill line grease drain (0.215 lb/,000 lb LWK). Eighty percent of the BOD was discharged during the production shift.

The origin of these wastewaters and the data backing these summary figures are discussed in the report.

These summaries clearly identify the sources of gross pollution and lead one to the process areas that must be modified. Table 3 lists the modifications made and the savings won. The flow was reduced by 41%; the BOD load was reduced 63%; and other pollutants were reduced in proportion to BOD. Many modifications required such a small investment that the first year savings paid for the installation. The net savings over a five-year period are impressive. The present value of the sequence of savings less the initial investment to make the change is listed as the net present value of savings. The total net present value of savings, over 5 yr at 10% interest, exceeds half a million dollars. This has impressed management with the enormous benefit/cost ratio of in-plant changes and wastewater reduction steps will be continued with enthusiasm.

Table 1. COST OF CHANGES AND SAVINGS RESULTING FROM CHANGES
(All changes were made in Madison except where noted)

Problem Area	Cost of change	Annual savings	Notes
Blood trough	$ 0	$ 40	——
Blood trough clean-up	$ 3	$ 40	——
Blood conveyor sprays	$ 0	$ 260	——
Hair chute - Davenport	$22,000	$19,406	——
[illegible] polisher shut off - Beardstown	$ 255	$ 626	——
Final carcass shower - Madison	$ 184	$ 853	——
Beardstown	$ 69	$ 2,080	——
Eyelids on floor	$ 86	——	Increased by product recovery value unknown
Brisket splitting Bone dust - carcass splitting Viscera pan wash sprays	$ 2,377	$ 4,078	——
Viscera pan wash solenoid valves	$ 1,285	$ 2,907	——
Hasher-washer blade removal	$ 275	$42,697 $96,244	Pollution reduction Increased byproduct recovery
Head washer	$ 0	$ 831	——
Rack washer	$27,000	$30,000 $ 4,050	Reduced labor Reduced pollution & water consumption
Chitterling washer - Beardstown	$ 78	$ 5,070	——

SECTION III

CONCLUSIONS AND RECOMMENDATIONS

Many older slaughtering operations were designed without consideration of wastewater treatment costs and problems. Water was used extravagantly, water was drained indiscriminantly across floors where it contacted blood clots and meat scraps, cleanup procedures habitually used vast amounts of water and too little dry cleanup, and the cost of pollution control was unknown or well hidden in overhead and utility costs. These older plants can be modified, often rather easily and without great expense, to reduce water use and lessen the amount of materials entering the drains as organic pollution.

The economic motivation for in-plant modifications to reduce or eliminate pollution have grown in recent years, and will grow even more in the next few years. The impact of P.L. 92-500 and its associated regulations for emission limits and industrial cost recovery where joint treatment is used represent a huge potential cost to the meat industry. There is no doubt that process modifications are an effective and economic escape from this threatened cost for pollution control.

CONCLUSION

Many specific problems and solutions are discussed in the report in Chapter 8. The magnitude of the wastewater flow and pollution load reductions achieved and the net savings are reported there as well. Broader conclusions are given here.

1. In the Madison plant the production shift discharged about two-thirds of the flow and 80% of the BOD. Even after making production shift modifications, while leaving the cleanup shift unchanged, the production shift would yield more wastewater (about 80% of the total) and more BOD (about 90% of the total). Making changes in both shifts gave the following result:

Flow : : : : 41% reduction to about 310,000 gal/day
BOD : : : : 63% reduction to about 2,250 lb/day
SS : : : : 63% reduction to about 2,300 lb/day.

After all changes, the cleanup shift represents about 25% of the flow, 9% of the BOD, and 17% of the suspended solids.

The opinion is often stated that the greatest target for reductions is the cleanup shift. The use of water for cleanup in the Madison plant was not terribly wasteful when the project began; nevertheless, the amount of water saved by making simple process modifications was 75,000 gal./day, a 58% reduction. This savings was due to process changes and not due to retraining cleanup personnel or enforcing stricter procedures for using hoses and the like. Impressive as this value is, shifting to dry conveyance of hair during the production shift represents greater savings.

Implementing dry cleanup procedures prior to wet cleaning gave a reduction in BOD load during the cleanup shift of 40%; the BOD load dropped from 510 lb/cleanup shift to slightly less than 300 lb/shift.

There are savings worth thousands of dollars annually to be made on the cleanup shift, even when the operation is initially reasonably efficient. Unless, however, the cleanup is obviously wasteful and sloppy, the greatest single improvements will be found on the production shift.

2. Dry conveyance of hair from the dehairing machine saves thousands of dollars on water purchase and disposal. It also reduces the load of suspended solids, BOD and other pollutants on the waste disposal facility. In the Madison plant over $20,000 could be spent to modify the dehairing machine to use dry conveyance and thousands of dollars would still accrue as savings within 5 years. Dry conveyance is used in many plants and the technology is well known.

3. Sluicing intestines, other viscera, and other scrap to rendering is a water use that should be minimized. Usually it cannot be eliminated and, therefore, some solid-liquid separation device may be needed prior to rendering. The separated liquid will be very high in all pollutants. It is the largest single source of pollution in the Madison plant. Modifications of this solid liquid separation will be rewarded handsomely by reduced waste treatment problems and increased rendering income.

In Madison the solid-liquid separation device, called the hasher-washer, first slashed the incoming intestines and other material with knives so the contents could be washed out. The slots in the dewatering drum were very large and gross amounts of solids spilled out with the water. Removing the knives so the intestines were sent to rendering intact can give an annual net savings of about $130,000, in spite of a slight reduction in the quality of the grease produced. Some plants have eliminated the hasher-washer, which is clearly a major step toward pollution reduction. Plants which have a hasher-washer should reevaluate immediately the need for this unit and, if it must be retained, make some modifications.

4. Dumping the contents of the hog stomach creates a very heavy load of suspended solids and other pollutants. Much of the contents are soluble and any contact with water gives an immediate rise in the soluble pollution load that must later be removed by expensive secondary

treatment processes. Dry dumping of stomachs would save greatly on water consumed and it would represent a major savings in pollution. In plants which already use dry conveyance for hair and do not use a hasher-washer, the stomach dumping and washing process may be the largest single source of pollution. The importance of this process has been clearly established. But a solution has not been developed. Methods for dry cleaning the stomachs need to be developed. Using smaller amounts of water for washing is a worthwhile objective, but this will not prevent the release of the potent soluble stomach contents as pollutants.

5. Other than the three processes previously mentioned, the main sources of pollution during the production shift are blood drippings and clots, and meat scraps dropped on the floor. Some easily installed and cheap remedies are screens around drains to hold back scrap until it can be shoveled into a container, catch troughs under the kill line to keep blood clots and scrap out of gutters and prevent leaching of organic pollutants, and curbs to divert water flow from floor areas which are covered with potential pollutants. Changing the water use habits and physical drainage patterns to eliminate water contact with meat tissue and bloody wastes is also a great help. Dry pick up of material from the floor intermittently should be practiced. These remedies play a dual role. They reduce the load of pollutants entering the drains and they increase the amount of material that can be rendered.

6. There is good correlation between BOD and COD; either measure could be used. Also, total Kjeldahl nitrogen is proportional to BOD, COD, SS, and could be used as a surrogate measure for screening studies. See Appendix D for details.

7. USDA regulations severely restrict the possibilities for reusing water except for sluicing hair and material that goes to inedible rendering. If sluicing must be used for transport of material, use recycled water and then reduce the volume of water to the minimum. Better yet, eliminate sluicing whenever possible and use dry conveyance methods. This eliminates leaching of organics from meat scraps and break up of blood clots.

8. The most difficult part of an in-plant wastewater reduction program may be winning the cooperation of the management who must approve the use of mechanics and other personnel to install the changes. Obviously, production cannot be interrupted by slacking on maintenance and process repairs, and mechanics are usually not overabundant. The best hope of winning this cooperation is to show estimated savings due to a particular change. In Chapter 9 a strategy is outlined for making the in-plant survey and developing a sequential program for attacking pollution problems and building your account of benefits. These are simple steps that can bring

attention getting benefits. The bulk of this report explains a very complete and rather massive data collection program and the documentation of costs and benefits of changes. A project of this magnitude is not required for a plant to begin reducing its pollution load and saving money through increased byproduct recovery, lower water bills, diminishing sewer surcharges, and fewer worries over the rapidly approaching Federal deadlines for implementing stricter pretreatment and industrial cost sharing codes.

RECOMMENDATIONS FOR FURTHER STUDIES

The recommendation that Oscar Mayer & Co. continue implementation of process modifications and exploration of in-plant conservation measures has already been accepted by plant management. The estimated savings from changes already installed stimulated this decision. There are some specific problem areas that deserve attention on more than a casual basis. These are identified as objectives for future special studies.

1. Invention of a new method for dumping and cleaning stomachs would be rewarding. Equipment manufacturers should be encouraged to help solve this problem.

2. Skinning hogs is starting to be used in some plants in place of scalding, dehairing, rosin dipping, singeing and manual shaving. This will eliminate many points of water use and drastically change the amount and nature of the pollution discharged from the pre-butchering processes. The water use and pollution generation of this growing technology should be characterized and conservation methods should be developed and incorporated into the design of new skinning operations.

3. Without doubt there are many simple process modifications that should be done and the decision making process is straightforward because benefits so obviously exceed costs. After these easy steps have been taken an industry should still want to reduce pollution rather than treat it or discharge it. This would be a public service and an economic reward to themselves in many cases. The economics become harder to quantify and the in-plant modifications become more expensive. Also, the uncertainties of future pollution control standards and costs complicate the problem. Work needs to be done to develop methodologies for determining the interaction between in-plant reduction and waste treatment costs. The true costs of waste treatment are often not known. The decision whether

to invest in major process changes or in expanded waste treatment facilities, or to go to joint treatment and pay surcharges is becoming more important economically. These engineering questions about treatment and cost allocations need to be answered.

SECTION IV

PLANT DESCRIPTIONS

GENERAL PLANT COMPARISONS

The Oscar Mayer and Company plants at Madison (Wisconsin), Beardstown (Illinois), and Davenport (Iowa) were studied. These three plants represent a wide variety of process technology and physical plant conditions. The Madison plant is old, crowded, and difficult to modify. The Beardstown plant is new, more spacious, and uses different methods for bleeding, dehairing, and intestine handling. The Davenport plant provides examples of some different technology.

The Madison plant was built originally by the Farmer's Cooperative in 1917, and was purchased by Oscar Mayer & Co. in 1919. Since the original purchase, the plant has expanded to over 1,000,000 ft^2 (93,000 m^2) of space devoted to slaughtering up to 1,000 head of hogs and 50 head of cattle/hr, and processing of ready-to-eat meats. The Madison facility also provides space for spice and pharmaceutical subsidiaries, a power plant and a large modern plastic package fabrication plant.

The Davenport plant was purchased in 1946 from Kohr's Packing Co. and since then has been greatly expanded. The present plant combines a 750 head/hr hog slaughtering facility along with an extensive ready to eat processed meats plant.

Built in 1957 as a hog slaughtering facility capable of processing 750 hogs/hr, the Beardstown plant has since been increased in size by 40% to provide space for a ham canning operation.

HOG KILL-CARCASS HANDLING (MADISON)

The hogs are driven singly from the stockyards into a conveyorized carbon dioxide (CO_2) gas immobilizer where they are anaesthetized (Figure 1). From the immobilizer the hogs are arranged on an inclined steel slat conveyor which has a blood trough along one edge (Figure 2). The unconscious hogs are killed by cutting the carotid arteries and jugular veins. The blood falls into the collecting trough and is pumped to the blood recovery system. The total bleeding time is 3.75 min from the time the hogs are stuck until they are dropped off the conveyor into the scald tank.

The raw blood from the blood collecting trough is piped to a steam coagulator and then to a centrifuge where most of the coagulated solids are removed.

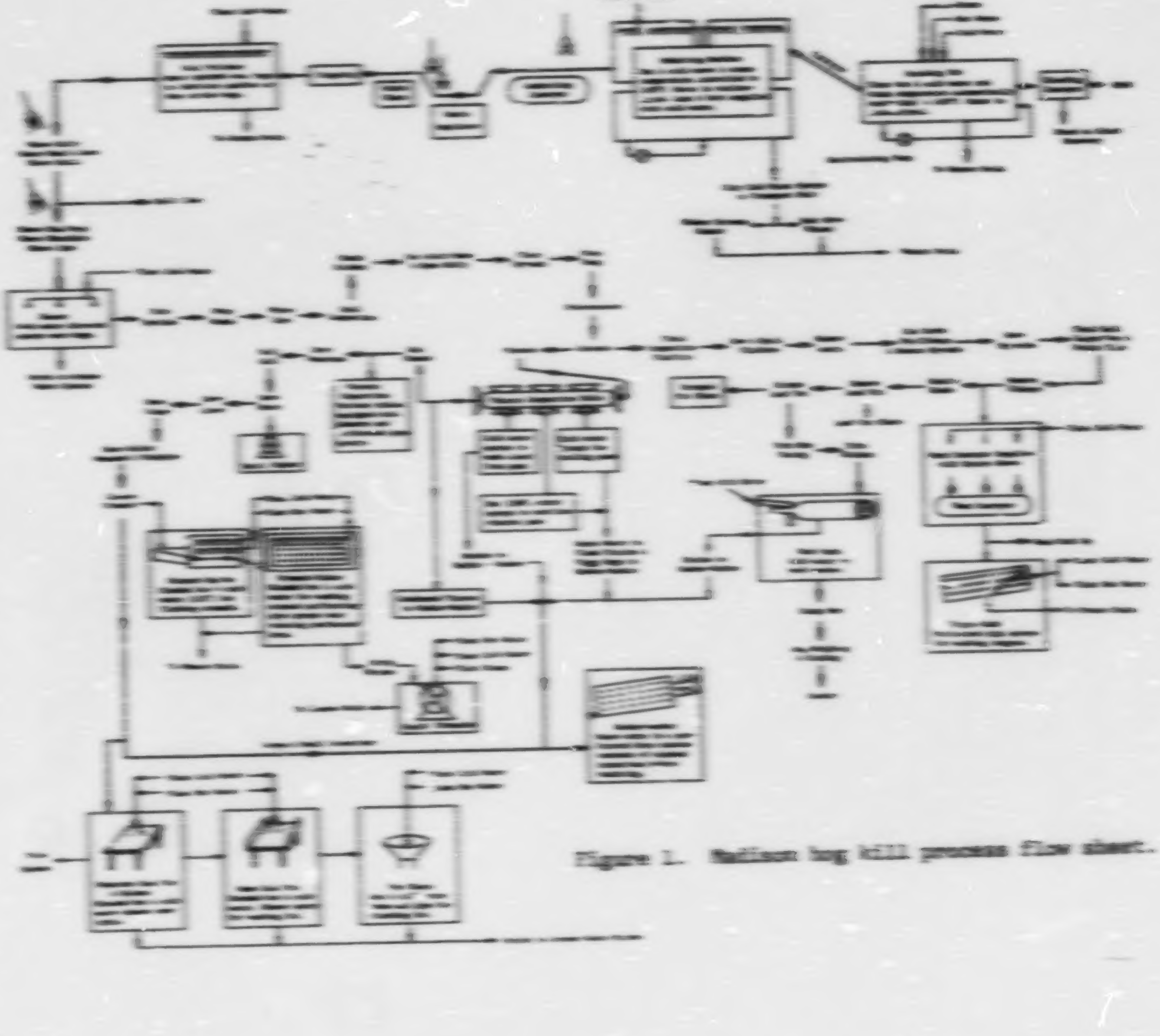


Figure 1. Madison hog kill process flow sheet.

Slotted conveyor over blood trough

Figure 2. Madison bleeding conveyor.

Figure 3. Madison scald tank (entry end).

The solids are sent by conveyor to a blood drier where it is dried to 10% moisture content for use as animal feed supplement. The liquid portion from the centrifuge is sent to the concentrator where some of the water is removed to produce a 60% protein material called tankage or liquid stick.

From the bleeding conveyor the hogs are dumped into a 140°F (60°C) scald tank (Figure 3). The carcasses are moved through the scald tank by a combination of mechanical "dunkers" and circulating hot water. Two hundred lb (90.9 kg) of lime is added to the 8,000 gal. (30.3 m^3) scald tank as a scald aid. The scald solution is maintained at 140°F by circulating it constantly and injecting steam into the recirculating pipe. The average time of a carcass in the scald tank is 5 min; however, because of the method of moving the hogs through the tank, this time can vary from 4 min to 5 1/2 min. The hog carcass is picked out of the scald tank and conveyed into the dehairing machine by means of an inclined conveyor (Figure 4). The dehairing machine itself is a two unit "Boss" dehairing machine. It consists of a series of rotating steel tipped rubber scrapers which rotate the hog carcass and scrape and pull off the scalded hair and toenails. A continuously recirculating heated spray showers the carcass in the dehairing machine to lubricate it and to convey away the removed hair and toenails. The water sprays in the final 6 ft (1.83 m) of the machine are potable cold watersprays required by USDA regulation. The hair and toenails removed from the carcass drop to a screen where a chain with "flights" scrapes it to a hair discharge chute. Water sprays at the hair discharge chute spray onto the hair and flushes it down a pipe into the manure water sewage system. Approximately 200,000 gal./day potable water is used to transport hair in this system. The almost completely dehaired carcass is expelled from the dehairing machine onto a steel slat conveyor. While on the conveyor the hind legs are slit and a steel gambrel is inserted behind the achilles tendon and the hog is hung onto a steel rail to the rosin dipilator (Figure 5).

In the dipilator the carcass is dipped into a molten rosin bath to be coated with 300°F (149°C) rosin except for the last 10 in. (0.25 m) of the hind legs. The rosin coated carcass is transported by means of a "live" chain through a rosin stripping cabinet where dry scrapers pull most of the rosin and hair off. The rosin-hair scrapings are remelted and rosin is recirculated back into the dipilator. There is some manual scraping of the rosin and then the carcass goes through another cabinet with rubber flails which remove the rest of the rosin. The second stripping cabinet has water sprays in it which lubricate the carcass. These sprays strip off and also carry away the fine bits of rosin. After rosin stripping the carcass passes through an 8 ft (2.44 m) long cabinet with open gas flames which singe off any hair not removed by the rosin and dehairing machine.

The head polisher is a large, concave, vertically rotating brush which brushes the head, neck and jowls of the carcasses to remove singed hair, rosin and dried blood. A water spray directed onto the brush flushes material away.

After the head polisher is the rail polisher. This is a 16 ft (4.88 m) long cabinet with two motor driven shafts, on which are mounted rubber flails. A water spray showers the carcass with 30 gal./min (1.89 l/s) of cold water to lubricate the carcass and flush off singed hair and rosin loosened by the

Figure 4. Conveyor into dehairing machine.

Combination blood
and water drain

Figure 5. Madison kill rail between gambreling and rosin dipilator.

rubber flails.

The final shaving and cleaning of the outside of the carcass is done manually. While a series of showers lightly lubricates the carcass, men use knives to scrape all surfaces of the carcass, remove toenails, and cut tissue from between the toes. The shaved carcass goes through the final carcass shower (Figure 6) where spray nozzles flush off loosened hair and scrapings. Any hair or soil remaining on the carcass after this point must be removed by excision.

The first step after the final carcass shower is removal of eyelids. The eyelids along with a large patch of skin and fat around the eye are cut off and discarded onto the floor (Figure 7). Periodically these scraps are swept up and taken to inedible rendering.

The head of the carcass is then nearly removed by cutting through the skin, neck muscles and between the first vertebra and the skull. The head is left hanging to the carcass by a narrow strip of flesh along the lower jaw.

USDA inspectors expose the salivary glands in the head to check for abscesses. The carcass is also checked for signs of dirt, hair or disease. An unacceptable carcass is tagged for trimming or disposal.

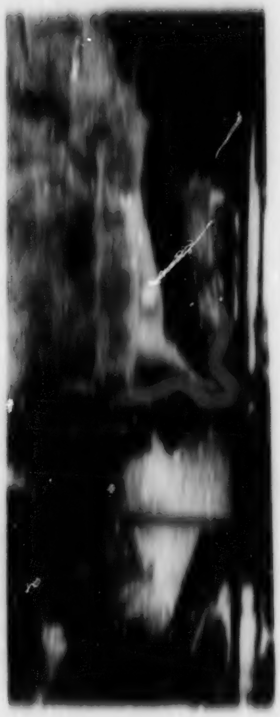
Next the brisket is split; i.e., the carcass is opened from the lower end of the sternum to the neck. Large quantities of blood clots and serum drop onto the kill floor (Figure 8). The next butchering steps open the abdomen, split the aitch bone, and free the urethra. The bladder, uterus (if present), and urethra are removed and discarded into a chute which carries them through the hasher-washer to an inedible cooker. The anus is cut around and freed from the surrounding skin and connective tissue.

A man standing on a treadmill synchronized to move with the hog carcass removes the viscera. All internal organs except the kidneys are removed and dropped into a viscera pan. Blood clots from the chest cavity fall onto the treadmill or onto the floor. The treadmill is continuously washed with cold water and sanitized with 180°F (82°C) water. Viscera work-up is explained later.

The carcass is split with a lubricated circular saw (Figure 9). Two or three small strips of skin are left uncut to hold the carcass halves together. Fat, blood, and bone dust from this operation drops to the floor and are carried into the floor drain.

Skin and fat around the stick wound, remains of the aorta, and sperm cords (of barrows) are removed and dropped onto the floor. Periodically these scraps are swept up for inedible rendering.

The kidneys are exposed. Bruises and blemishes are trimmed from the carcasses prior to final USDA inspection. Trimmed pieces are put into containers or dropped onto the floor. They are later swept up for inedible rendering. The kidneys are removed and sent to the offal department.



Lower spray used only when sows are being washed.

Figure 6. Madison final carcass shower.

Figure 7. Madison kill line at eyelid removal station.

Blood Clots From Brisket Splitting

Combination Blood And Water Drain

Blood Gutter Under The Kill Rail

Note The Accumulation Of Blood
Clots In The Gutter

Figure 8. Madison kill line near brisket splitting station.

Water Spray

Figure 9. Carcass splitting saw.

The carcass and head pass through sprays which wash blood and stomach contents from the head (Figure 10). After washing, the head is removed from the carcass and skinned. The cheeks, jowls, scalp, tongue and other muscle tissue are removed for use in processed meats. The skull is split and the pituitary and hypothalamus glands are removed for sale to pharmaceutical manufacturers. The skull and jaw are sent to inedible rendering.

The USDA inspected carcass is marked with an indelible stamp. Leaf fat, which lines the interior dorsal sides of the carcass, is pulled out and sent to lard rendering. Hand scrapers are used to remove loose fat and tissue from interior and cut surfaces of the carcass. The tissue removed is collected in a trough, and pumped to lard rendering (Figure 11).

Hand operated neck washers are used to remove blood clots and fatty tissue from the stick wound (Figures 12 and 13). Material washed from the wound falls to the floor and is flushed down to the hasher-washer.

The carcass is weighed, sent to the cooler, and held for butchering the next day.

VISCERA HANDLING (MADISON)

Viscera is removed from the carcass and dropped into a viscera pan mounted on a conveyor. The viscera is examined by USDA inspectors for signs of disease. Viscera approved by the USDA inspectors goes to the work-up table; the organs are separated and sent to the offal department for further handling. Viscera condemned by the USDA inspectors is dumped into a chute to the hasher-washer and from there to inedible rendering. The viscera pans are continuously washed with cold water and sanitised with 180°F(82°C)/ USDA rules. Hearts are separated and slashed to expose clotted blood. The hearts are washed in a tumble washer in cold running water for 3 to 5 min to remove the blood (Figure 14). The clean hearts are laid on trays and chilled. Blood clots, parasite spots and membranes are trimmed from the livers. The livers are hung on a rack and chilled.

The small intestines are sluiced to the hasher-washer where they are cut open, rinsed, and sent to inedible rendering. Some small intestines are ground, preserved in barrels, and kept for heparin extraction. Stomachs are slit, rinsed, and tumble washed (Figure 15). The mucosa is stripped from the stomach wall and held for pharmaceutical purposes. The stomach is scalded and then frozen for animal food (Figure 16). The pancreas is washed in a small tumble washer and chilled.

The caul fat is hand stripped from the spleen, hand rinsed and then transported manually to lard rendering. When lungs are being saved for animal food they are weighed, packed into boxes and frozen. When lungs are not being saved, they go through the hasher-washer to inedible rendering. Spleens are rinsed and frozen for animal food. When gall is being saved, the empty gall bladders are dumped to inedible rendering. If gall is not being saved, the intact gall bladder is sent through the hasher-washer to inedible rendering. The large intestine (black gut) is sent through the hasher-washer where they are slashed,

Figure 10. Madison head washing sprays.

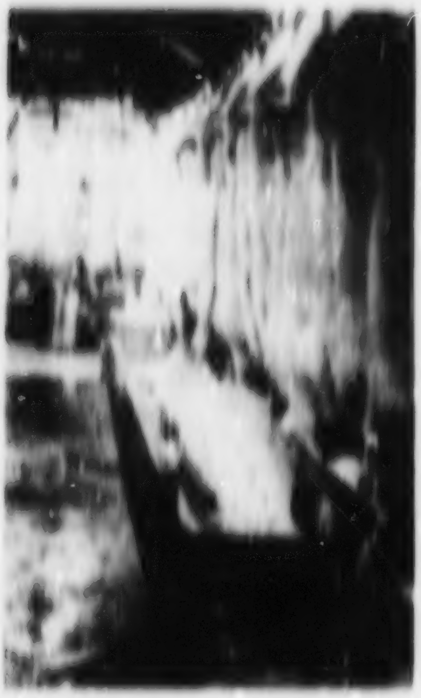


Figure 11. Madison plant scraped fat catch trough.

Knobbed metal brush
Water supply to washer

Figure 12. Manual neck washer.

Figure 13. Accumulation of fatty connective tissue on floor of manual neck washing area.

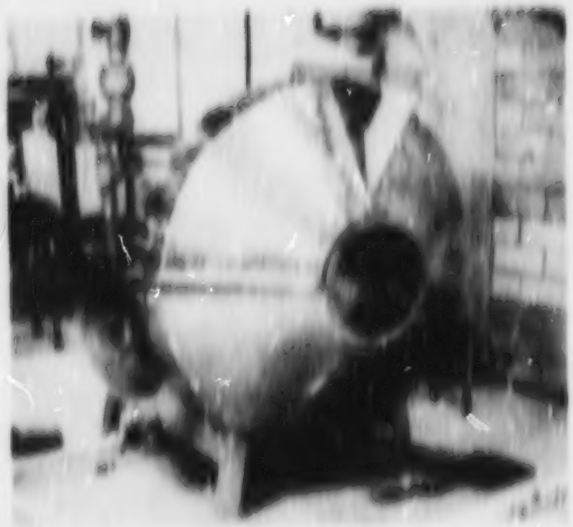


Figure 14. Heart tumble washer.

Tumble
Washer
Sampling Hub
For Stomach
Slitter And
Washer

Figure 15. Stomach slitter and tumble washer.

Figure 16. Stomach scalder.

rinsed, and sent to inedible rendering. When kidneys are being saved, they are boxed and frozen. When they are not being saved, they are sent to inedible rendering.

HAIR SAVING OR DISPOSAL (MADISON)

Prior to 1975, from May through September the hair removed in the dehairing machine was sluiced to the sewage pretreatment plant, and screened. The hair and toenails were landfilled. From September through May hair and toenails were sluiced from the dehairing machine to a hair cleaning department; the sluice water was removed by a shaker screen. The damp hair was washed in a mild caustic solution and rinsed with warm potable water. The clean hair and toenails were conveyed to a steam-heated mesh conveyor and dried. A vacuum pick-up transported the hair from the dryer to a baler (the heavier toenails not picked up by the vacuum drop into a trash collector). The baled hair was overwrapped with burlap and held for shipment. Since 1975 hair was no longer saved.

DAVENPORT PLANT HOG KILL

The basic processes used at Davenport are the same as at Madison except for minor differences in layout and water use. In the Davenport plant, hair removed in the dehairing machine is dropped by chute to a truck body for landfill disposal or to hair saving during the proper season instead of being sluiced to its destination. Davenport also uses catch pans with weirs in some carcass washing steps to keep fatty tissue out of the drains.

BEARDSTOWN PLANT HOG KILL

In Beardstown hogs are electrically stunned instead of being gas anesthetized as in Madison and Davenport. The hogs are then shackled, bled out over a pit as shown in Figure 17. Blood from the pit is drained to the blood recovery system.

The shackled hogs are dragged through the scald tank. Because they are dragged through rather than being free floating (as in Madison and Davenport) the time they spend in the scald tank can be more closely controlled.

In Beardstown the large intestines of hogs are processed to make chitterlings. The large intestines are separated from the small intestines and conveyed to the chitterling wash area. The intestines are pulled apart from their connective tissue, slid onto the chitterling washer rail, slit open and flushed with potable water in the washer (Figures 18 and 19). The chitterlings are then chilled, packed in plastic cartons and frozen for sale.

Beardstown uses water recycled from the grease flotation tank in the sewage treatment plant to sluice the hair and toenails from the dehairing machine back to the shaker screens in the sewage treatment plant. Beardstown does not use

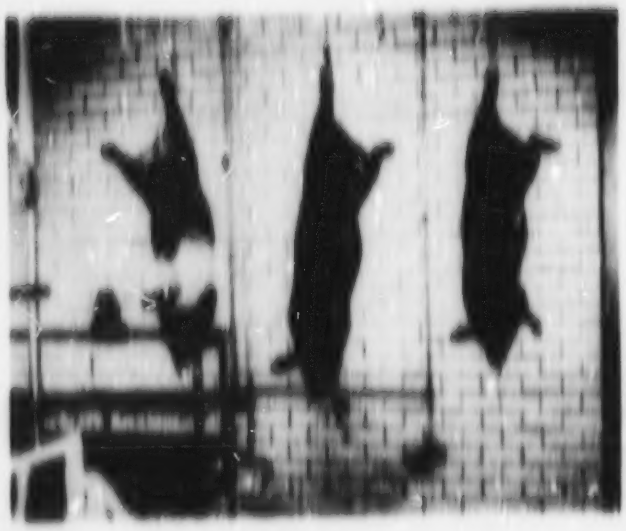


Figure 17. Build-up of blood on platform at Beardstown bleeding area.

Figure 18. Original chitterling washer sprays.

New type sprays
Bucket conveyor

Figure 19. Beardstown chitterling washer.

a rosin dipilator for hair removal.

WATER SUPPLY

The Madison plant has three wells and is starting up a fourth one. The average flow of the three wells is 5,000,000 gal/day (219 l/sec). Water is pumped from the wells to a central reservoir. Water is constantly pumped from the reservoir and used as ammonia condenser cooling water for the ammonia refrigeration units and returned to the reservoir. Water from the reservoir is pumped throughout the plant for use. The Madison plant also purchases 2,000,000 gal/day (87.6 l/sec) of water from the City of Madison. Most of the city water is used for the production of processed meats and little is used on the kill floor except in drinking fountains. The total water use in the kill floor is not metered directly; it is not possible to isolate water supply lines to the kill floor. Some water on the kill floor is used more than once. The water used to wash the viscera pans, the treadmill, and the viscera work-up table is also used to sluice condemned viscera and intestines to the hasher-washer.

The Davenport plant has four wells on the plant property which supplies most of the water for the plant. Some water is purchased from the city as necessary to maintain the reservoir level, and some city water is piped directly into the plant for use in processed meats manufacturing. The well water is pumped through the ammonia condensers before going into the reservoir for use in the plant. Some water is drawn from the reservoir through the ammonia de-superheater and into a hot well to use as pre-heated water for the plant hot water system.

The total water supply for Beardstown comes from three wells on the property which pump an average of 1,420,000 gal. (5,375,228 liters) of water per manufacturing day.

WASTEWATER HANDLING SYSTEMS

Madison

The Madison plant has segregated wastewater collection systems. Sanitary wastes from plants and office toilets are discharged directly to the Madison Metropolitan Sewage Treatment Plant. Cooling water from plastic extruders with drains and roof drains empty directly into the city storm sewers which discharge into the Yahara River.

There are four drainage systems from the kill floor of the Madison plant. These are shown in Figure 20. They are the blood collection system, the hasher-washer drain, the grease water drains, and the manure water drainage system. Where large quantities of blood drip from the carcass there are dual drain openings in the gutters. One opening goes to the blood collection system; the other is the entry to the grease water system. During production, blood is collected in the blood recovery system whenever this can be accomplished without having the blood diluted by water from adjacent areas. When blood is being

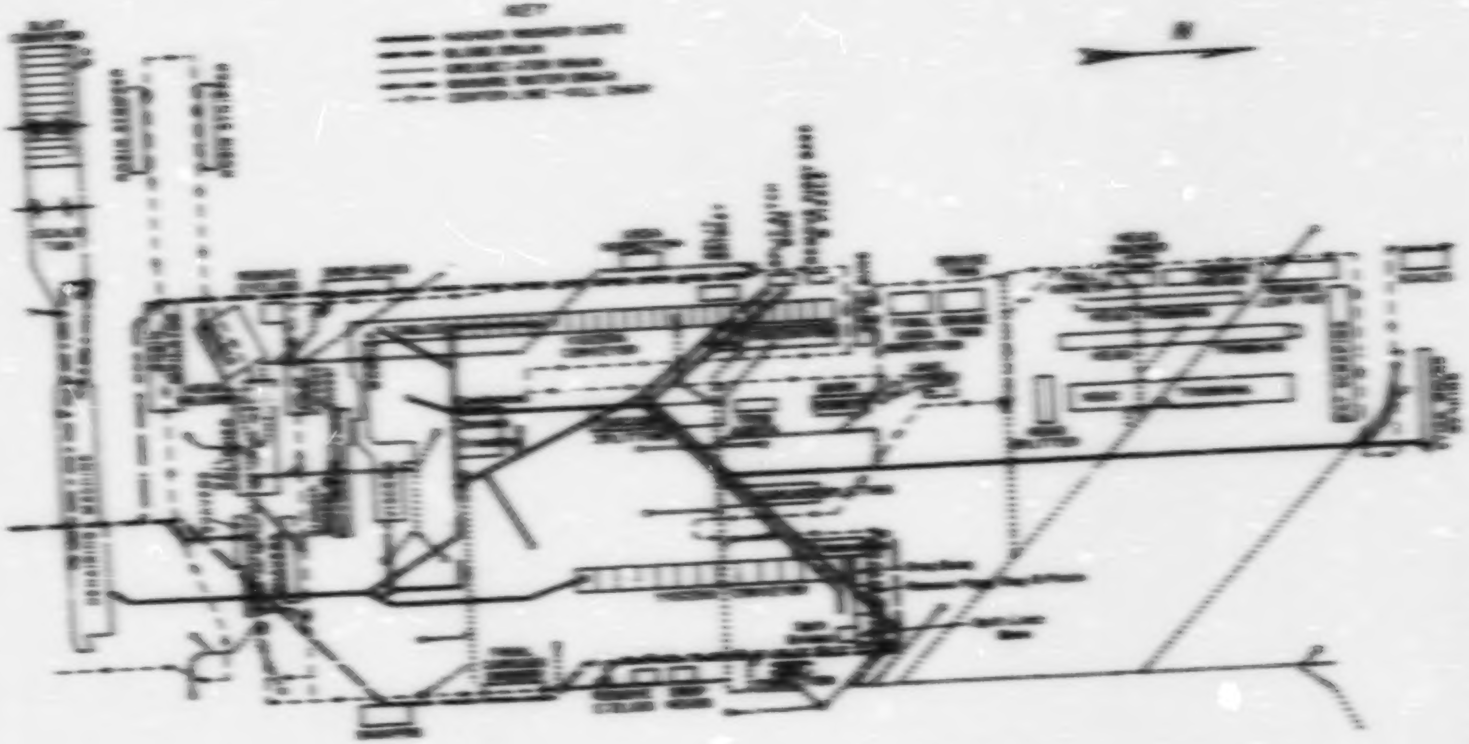


Figure 20. Nations Hill floor drainage system.

collected for recovery, the grease water system is plugged. During cleanup, the blood drains are closed and the adjacent grease water drains are opened. The blood collection serves primarily the bleeding conveyor area, but also the drain gutters under the kill chain.

The manure water drainage system collects water from the stockyards, the stomach dumper, the dehairing machine, hair wash, and the scald tank. The wastes go to a pretreatment plant (Figure 21) where the large solids are removed by a shaker screen and are disposed of in landfill. The wastewater then goes into a settling tank where the heavy solids settle out and are pumped to a sludge holding tank. The liquid wastes are metered and joined with the grease water effluent and is piped to the treatment plant. The hasher-washer drains are merely greasewater drains used to carry heavy solids. This system is used to transport condemned viscera, unused intestines, pissles, piggy bags, and bungs to the hasher-washer using wash water from the viscera pan washer and other places. At the hasher-washer the intestines are slashed into pieces and the contents are flushed out by passage of the transport water over and through the chopped up viscera. The solids from the hasher-washer are sent to inedible rendering and the effluent goes into the plant greasewater drainage system.

The grease water system contains the effluent from all of the plant floor drains both from the manufacturing and slaughtering parts of the plant. It also contains the effluent from the hasher-washer in the inedible rendering department. Waste water from the kill floor goes to a catch basin where fatty material is floated off and sent to inedible rendering. The effluent from the catch basin is pumped to the pretreatment plant into a dissolved air flotation tank where more solids are removed for inedible rendering. The effluent from the dissolved air flotation tank joins the effluent from the manure water settling tanks and is pumped across a rotating arm trickling filter, an intermediate clarifier, a fixed bed trickling filter, a final clarifier (Figure 21) and then to Madison Metropolitan Sewage District's Treatment Plant. The sludge from the clarifiers is pumped to a sludge holding tank and then through a vacuum filter. The solids from the vacuum filter are disposed of in landfill.

Davenport

The Davenport plant also has four wastewater drainage systems. The clear water drainage and the sanitary sewers are combined and go directly to the City of Davenport Sewage Treatment Plant. Kill floor drainage in Davenport is the same as in Madison. The manure drains collect water from the stomach washer, stockyard drains, dehairing machine and scald tank as in Madison. The effluent from these drains is treated by a "Roto-Strainer" where the solids are removed for landfill disposal. The effluent from the "Roto-Strainer" is sent to the City Sewage Treatment Plant.

Grease drains collect wastewater from slaughtering and manufacturing plus water from the hasher-washer. These effluents are treated by a pair of "Roto-Strainers" where most of the solids are removed and sent to inedible rendering. The "Roto-Strainer" effluent goes to dissolved air flotation tank. The skimmings from the dissolved air flotation tank are pumped to inedible rendering

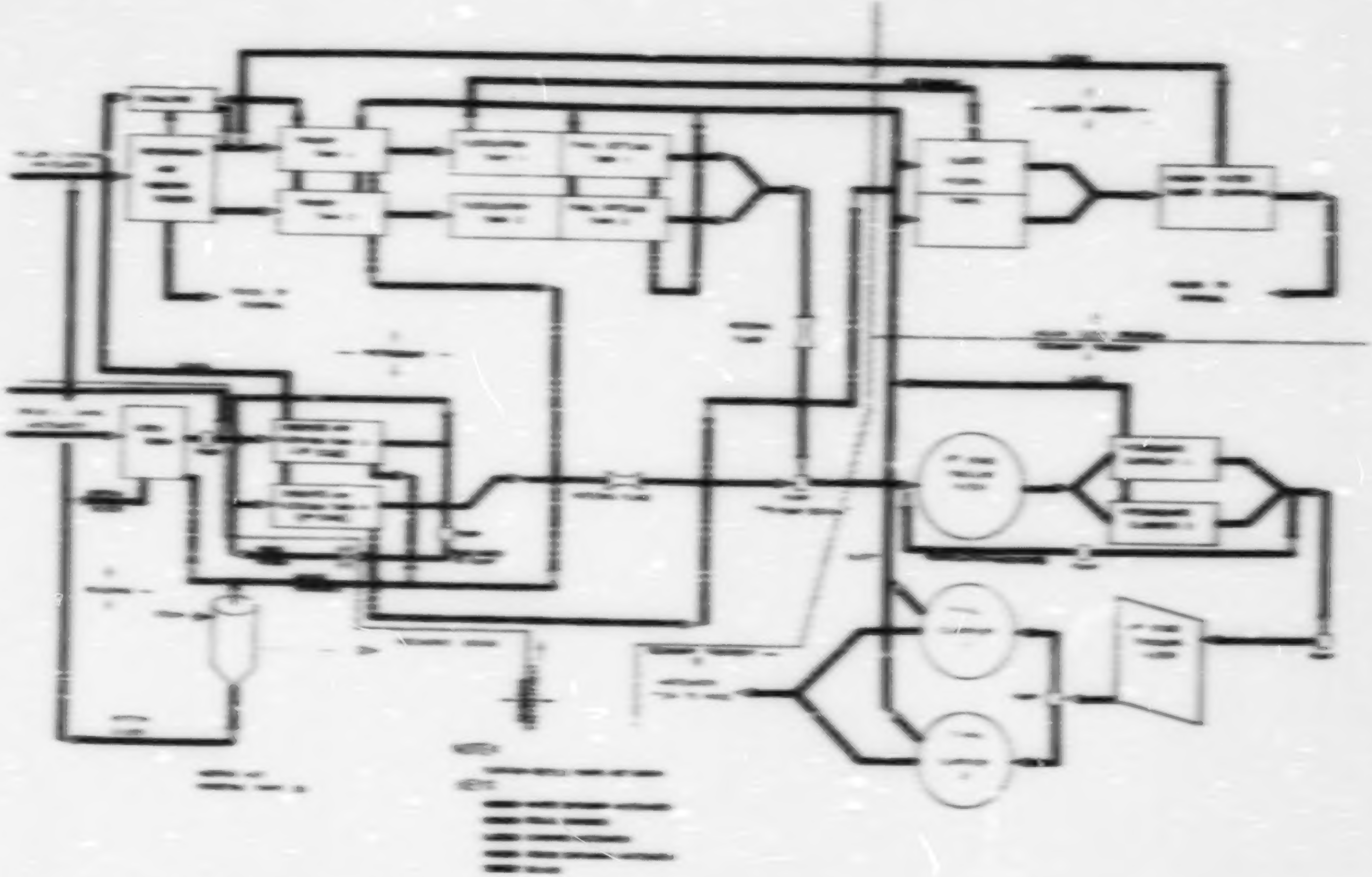


Figure 21. Holston plant wastewater treatment flow diagram.

and the bottom solids are pumped across the manure water "Roto-Strainer." The effluent from the dissolved air flotation tank is sent to the city sewage treatment plant.

Beardstown

The Beardstown plant has four wastewater drainage systems. Sanitary wastes from plant and office toilets drain to a wet well. From the wet well the effluent is pumped to an anaerobic lagoon. Clear water wastes from the roof and yard drains are allowed to run off onto the yards into the soil. The kill floor drainage for Beardstown is also the same except there are no blood drains anywhere except in the bleed area. In Beardstown where the hogs are shackled and stuck, they bleed out better and there is very little blood which falls to the floor as compared to Madison and Davenport.

Manure containing wastewater from the stomach slitter and stockyards drains to a wet well. From the wet well the effluent is pumped across a shaker screen. The solids from the shaker screen are sent [illegible] landfill, the effluent drains to a settling tank. The sludge from the settling tank is pumped to a sludge holding tank and to a vacuum filter. The solids from the vacuum filter are disposed of in landfill. The effluent from the settling tank is pumped to the same wet well as the sanitary effluent and is pumped to an anaerobic lagoon. The hair containing effluent from the dehairing machine flows across a shaker screen where the solids are removed for landfill disposal, the liquid flows into the same wet well as the sanitary wastes and is pumped to an anaerobic lagoon.

Grease containing wastewater from the plant floor drains flow to a wet well in the sewage treatment plant. From the wet well the effluent is pumped to a dissolved air flotation tank. The flotation grease from the tank is sent to inedible rendering. A part of the water in the flotation tank is pumped back to the plant to use for transporting hair from the dehairing machine and the rest goes to a wet well from which it is pumped to an anaerobic lagoon. From the anaerobic lagoon, the effluent flows into an aerated intermediate lagoon and then into a final aerobic lagoon before discharging into the Illinois River.

SUMMARY

This description of the three slaughtering plants was most detailed for the Madison plant because most of the process sampling was done there. Sampling was done in Beardstown only on processes that used different technology or on processes that do not exist in Madison (i.e., chitterlings). The Davenport plant was characterized by comparison with Madison or Beardstown.

The arrangement of the Madison kill floor and the wastewater collection system are important to remember through Chapters V to VIII. The sampling procedures and characterization in several instances were constrained by this physical arrangement. In Chapter VIII additional photographs and data that show rearrangements of processes pictured in this chapter and the savings achieved are also presented.

SECTION V

CHARACTERIZATION OF THE PRODUCTION SHIFT

INTRODUCTION

The normal water use and wastewater production of the killing and production shift and the cleanup shift have been characterized. This chapter deals with the production shift. The next chapter deals with water use and characterization during cleanup. The location of the sampling stations, the laboratory procedures, and the general methods used for sampling and flow measurements were the same for both the production and the cleanup shift. Minor changes from these general procedures or specific details about a particular sampling location will be pointed out in the text.

LABORATORY METHODS

All laborato[illegible]alyses were done in accordance with standard accepted procedures accordi[illegible] to standard methods and EPA instructions for chemical analysis (3). Twice during the project unknowns from the EPA were analyzed as a check on the accuracy of the procedures being used and the procedures were shown to be acceptable. Here only a few special points are mentioned. Many of the samples contained blood. Some of the samples are known to be contaminated primarily with blood and, therefore, precautions were taken to be sure that an acclimated bacterial seed was used in BOD tests. A bacterial seed colony was established in the laboratory. This colony was fed blood periodically so that the organism would be certain to be acclimated. All BOD's were seeded with this bacterial culture. COD's were run on all samples as well as BOD's and for most samples the total organic carbon was run as well. These three measurements, TOC, BOD, and COD, provide a check on each other and the consistency of variations, one parame[illegible] with another, gives additional confidence in the quality of the data w[illegible]h has been used to characterize the system. Likewise, complete analyses on solid residues was done. The other most useful parameter seems to be total Kjeldahl nitrogen.

Correlation of one parameter with the others will be discussed later. The important point here is that increases in one parameter generally were associated with increases in the others, thus, strengthening one's confidence in the quality of the data and of the skill of the laboratory analyst.

WASTEWATER FLOW MEASUREMENT

The accurate measurement of wastewater flow is an important step in the characterization project. In a few processes the effluent was known to be equal to the influent and it was possible to monitor the influent with totalizing water meters. In other situations direct metering of the water supply was not possible; the effluent was not equal to the influent because of spillage and splashing; the plumbing to the process was so complex and would require so many water meters that this was not practicable; or there was intermittent water use with hoses and off-on operations. In these instances a tracer dilution method was used (the tracer was lithium chloride). Or the time required to fill a container of known volume was measured and the flow rate was calculated.

The procedure of timing the filling of known volume was used for hoses and other intermittent flows. These estimated flow rates were used in combination with observed normal duration of use of hoses and other devices to estimate total volume contributors of wastewater.

The lithium chloride dilution technique involves the injection of a concentration of lithium chloride solution at a known and uniform rate into the wastewater flow. Samples of the lithium/wastewater mixture are collected downstream after the lithium has become mixed uniformly with the wastewater. Lithium is an excellent tracer for this purpose because it does not adsorb; it can be detected by atomic absorption in very low concentrations. There is no hazard associated with its use in the food industry; nevertheless, care was taken to see that no lithium contamination of the food product could occur. The wastewater flow rate is calculated from the ratio by which the lithium has been diluted. This calculation is very simple because the volume of lithium solution injected is extremely small in comparison with the wastewater flow, so that the total flow is not essentially unchanged.

WASTEWATER SAMPLING METHODS

Collection of representative wastewater samples was difficult in many instances due to the heterogeneous nature of the waste and physical restrictions of the existing processes and of the existing sewer system.

At some locations it was known that the flow would be constant during the production shift. Often even in these locations grab samples were taken and later were mathematically composited. This gave information about variability within the process and additional information regarding correlation of one strength parameter with another.

In several cases it was not certain that the flow was constant during the day. Some drains that collected flow from several processes were sampled and some of those processes had intermittent water use, intermittent cleanup operations, and other variations in water use that precluded compositing samples. In these locations, either numerous grab samples were used or composites were prepared over a short time period of 10 to 30 min. These grab samples could be used with flow information compiled over the time of study to make estimates of total pollutant discharge and to check assumptions regarding patterns of water use and of wastewater pollution.

Collection of samples was automated when possible by using an ISCO sampler. This device collects 500 ml portions of wastewater at a frequency which can be set as short as every 15 min. The sample volume is deposited in an individual plastic bottle (or a clean glass bottle when grease was to be analysed). Automatic sampling was feasible only in locations where the wastewater was free of large and heavy suspended solids. Where heavy solids, hair or other clogging materials were evident, samples were collected manually in a small bucket. A number of these would be collected over a short time period, and composited in a large bucket which was thoroughly mixed. The composite sample sent to the laboratory was a portion of the well mixed contents.

Matching the sampling method to the particular sampling location was very important. Care was taken to obtain representative samples. Whenever an automatic sample was used, special precautions were observed to avoid clogging of the perforated head on the suction tube and to avoid clogging of the tube itself.

WASTEWATER SAMPLING STATIONS

Whenever possible, sampling points were chosen which would isolate the flows from specific pieces of equipment or from specific processes. This was not entirely possible and the flows and characterization of some processes are combined with others. Sampling points located on the kill floor or one floor below are shown on the Madison kill floor drain plan (Figure 22). Other drains not shown are located in the hair saving area or in the variety meats department.

Bleed Area Floor Drain

This drain receives drainage from the floor around the bleeding conveyor and from the conveyor cleanup. During production, there is no flow in this drain.

Bleed Conveyor Blood Drain

The blood trough runs along the inclined bleeding conveyor and collects the blood and channels it into a blood pump on the floor below where it is pumped to the blood drying system. During production there is no wastewater flow in this drain.

Bleed Conveyor Wash Drain

Spray nozzles continuously rinsed the blood from the bleeding conveyor during production and the first part of cleanup. These sprays were the total waste flow for this drain. Discharge was drained into the plant greasewater drainage system. The drain was sampled from the end of the drain pipe before it discharged into the floor drain. The flow rate was estimated by collecting a timed sample in a calibrated vessel.

Scald Tank

There is no flow through the scald tank during production. The tank is

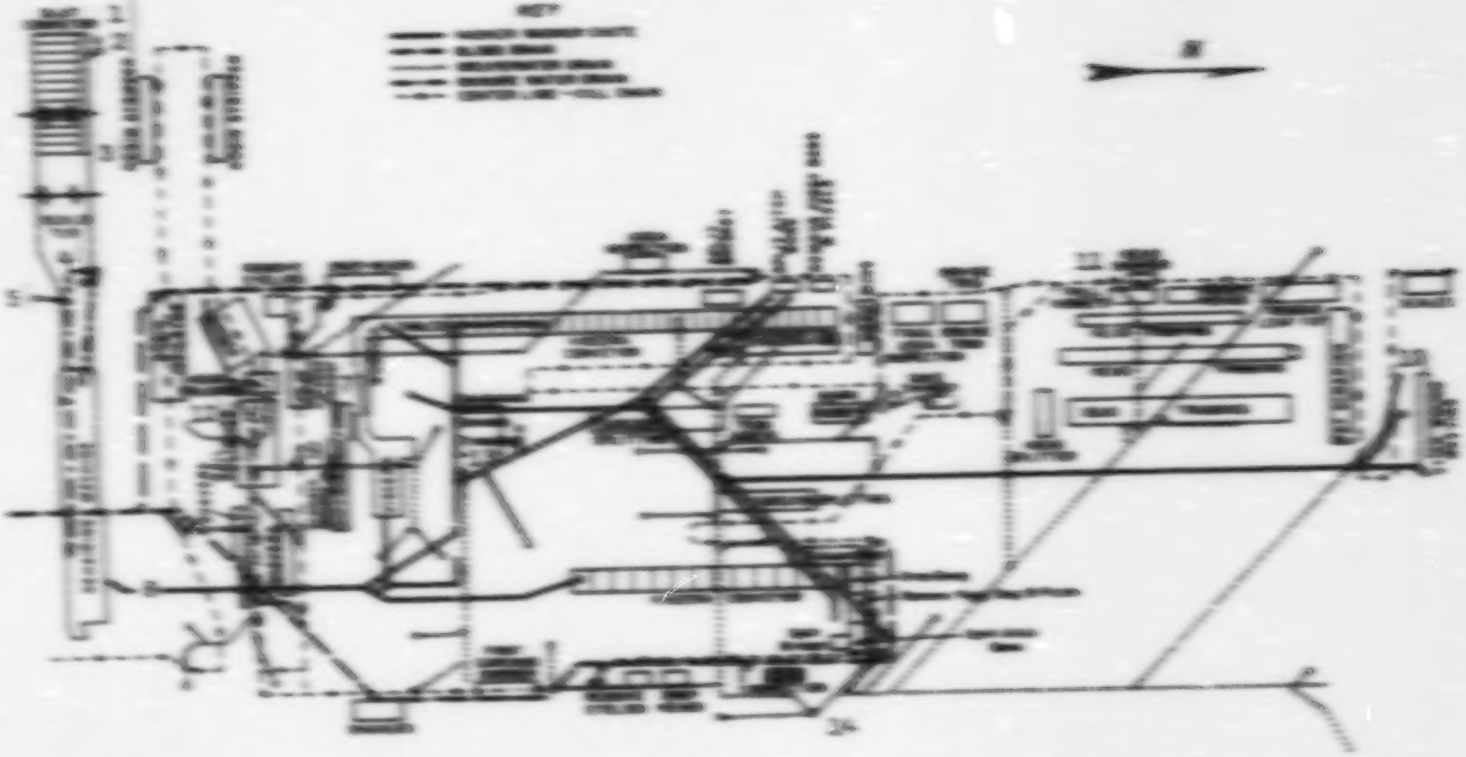


Figure 21. [illegible] Hill flow sampling points.

filled in the morning, and makeup water is provided by the steam which is injected to heat the tank. The volume of the tank is known. The pollution load from the scald tank was estimated from samples of the tank contents taken during the day. The scald tank is emptied into a manure drain during cleanup. The dehairing machine cleanup waste goes into this same drain.

Dehair Floor Drain

The waste discharge into this drain changes from season to season. In summer, hair is not saved and the dehair floor drain collects the total production and cleanup effluent from the dehairing machine. This includes dehairing machine overflow and removed hair and toenails, plus the drainage and cleanup of the scald tank. When hair is being saved the drain collects only overflow from the dehairing machine during production. This drain discharges into the manure wastewater system.

The flows into the dehair floor drain were estimated by placing water meters on every source of water contributing to the drain. The meters were read before and after production each day to obtain flow data both for production and cleanup.

Wastewater samples from this drain were obtained in three different ways: (1) Grab sampling by inserting a hand dipper into a clean-out pipe in the drain, (2) Automatic sampling with air operated sampler placed in the drain pipe three floors below the dehairing machine. The sampler is comprised of an automatic electric timer, a solenoid valve controlling an air line, and a 2 in. rubber lined "squeeze valve." When air pressure is maintained on the valve, the rubber lining of the valve is closed. When the timer is tripped, the air is exhausted and the valve opens allowing flow through the valve into a collection bucket. The advantages of this sampler is that it allows taking samples which contain heavy solids without the danger of solids blocking the valve and keeping it from closing, (3) Automatic sampling with an ISCO Sampler through a clean-out pipe in the drain. The strainer on the end of the ISCO was covered with a screen to prevent heavy solids from plugging the intake hose, and the strainer was inserted into the drain pipe so that the suction hose was constantly flooded. The sampler was set to take individual samples every 15 min during production and cleanup. Methods (1) and (2) were used nearly all the time during production. Method (3) was operable during cleanup.

Rosin Stripper Drain

The rosin stripper drain collects flow from the carcass sprays in the rosin stripping area. Most of the rosin is stripped dry from the carcass. The residual rosin is hardened by a cold water shower, loosened by beating the carcass with rubber paddles, and rinsed off by cold water sprays. There is no flow in this drain during cleanup. The effluent from this shower during production goes into the plant greasewater drainage system.

Samples were obtained manually from the drain trap in the shower at various times during production. Flow data from this drain was obtained by the lithium dilution method.

Rail Polisher Drain

The rail polisher drain collects only water from the rail polisher and empties into the plant greasewater drainage system. Characterisation samples were taken by placing the suction end of the ISCO Sampler in the drain trap in the floor to take individual samples at one-half hour intervals during the production shift.

Flow rates were obtained with a totalising water meter on the water supply by taking readings at the beginning and end of the production shift.

660 Grease Drain

This drain was sampled through a clean-out port in the drainpipe located on the floor below. The drain collects wastewater from the final carcass shower, lavatories, sprays, and floor drains in the immediate area. This drain empties into the plant greasewater drainage system.

Samples were obtained through the clean-out port in the drainpipe automatically with an ISCO Sampler. Samples were taken both during production and cleanup.

Flow was obtained by the lithium dilution method. The ISCO Sampler was used to collect the lithium samples from the drainpipe clean-out port at 15 min intervals.

Carcass Shower Drain

The carcass shower drain flowed into the 660 grease drain. This drain was sampled separately, however, at the drain trap. There was no flow from this source during cleanup. Samples were taken at the entry of the wastewater into the floor drain at different intervals during production. Flow rates were obtained by direct metering of the water supply to the shower. The water meter was read before and after production to determine the flow rates for production and cleanup.

Center Grease Drain

The total flow in this grease drain was from three floor drains. When the 330 kill line was not operating there was no flow in this drain during production. When the 330 kill line was running, the total flow from the final carcass shower went into this drain. Samples were obtained through a clean-out port in the drainpipe on the floor below at various intervals during prouction and cleanup. Flow rates for this drain were obtained by the lithium dilution method.

330 Grease Drain

This drain received floor drainage from more than one-half of the kill floor and includes floor drains and lavatories, as well as the head washer. This drain flowed into the plant greasewater drainage system. Samples were obtained through a clean-out pipe on the floor below. Sampling was done both with the ISCO Automatic Sampler and by manually taking grab samples at various times during the production and cleanup shifts. Flow data were obtained by the lithium dilution method.

Head Washer

The head-washing sprays remove blood and stomach ejects from the head before it is removed from the carcass. The effluent from this washer flows into the 330 grease drain. This drain was sampled as a part of the 330 grease drain using an ISCO Sampler through a clean-out in the drainpipe. The flow rate from the head washer was obtained by taking a timed sample of the spray nozzles in the washer in a calibrated container.

Stomach Washer

All flow from the stomach slitter-dumper and tumble washer went into a drain hub on the kill floor and from the hub into the manure wastewater system. Samples were taken by using a dipper to reach down into the hub. This gave a composite of flows from all parts of the stomach washer. Ten to twelve dips were made from the hub to fill a sample container to insure that the sample was representative of the flow.

Flow data was obtained by the lithium dilution method. Lithium stock solution was dripped into the collecting funnel under the slitter-dumper and the samples were taken in the drainage hub. Several dippers of the effluent were composited to insure that the sample was representative. An off-shift simulation was performed to determine which of the units contributed the majority of the wastewater.

Hasher-Washer Drain

This drain collected wastewater from the viscera pan washers, the eviscerating conveyor washers, the viscera work-up table, and the stick wound washing. Water is used to sluice condemned viscera, large and small intestines, the bung, and other inedible parts to the hasher-washer. At the hasher-washer blades slash open the intestines and the transport water carries the intestinal contents, blood clots, and small pieces of fatty tissue through holes in the dewatering drum into a shallow curbed tank. This effluent goes into the plant greasewater drainage system. Solids retained in the perforated drum go to inedible rendering.

Samples were taken by placing open containers under the dewatering drum and allowing them to fill over a 2 to 3 min interval. Some samples were also taken using a wide scoop shovel to pick up the effluent from the shallow tank bottom. Several scoops were used to fill each sample container. Samples were taken at various intervals during both production and cleanup shifts.

To determine flow on the production shift, special off-shift simulation studies were made at night after the plant was completely shut down. Lithium was injected into the sewer which collected the flow, and the flow was estimated by the lithium dilution method. It was possible also to identify the volumes of hot and cold water used in this same way. The results are presented in detail in the characterization section.

Neck Washer

The neck washer drain collected flow from the machines which are used to wash blood clots from the neck of the carcass. This flow went into the hasher-washer drain and from there into the plant greasewater drainage system. Manual grab samples were taken at the floor drain. Flows were estimated with the bucket and stop watch method. The total flow in this drain was the combined flow of two or three of these machines, depending on the kill rate.

Summary of Sampling Methods

Table 4 summarizes the flow measurement and sampling methods used at each station during the production shift.

WASTEWATER CHARACTERIZATION

Production of pork was quite variable over the period of study. Therefore, it was necessary to make the characterization on the basis of an average production day. Production records have been summarized in Figure 23, which shows the length of the operating day, and in Figure 24, which shows the distribution of live hog weight killed per day. The two humps in the length of the production day result from infrequent periods of extremely high production. The normal work day was defined as the average value, that is 7.79 hr. During a work day of this average duration, the hog production varied between 600 hogs /hr and nearly 1000 hogs/hr. When the number of hogs processed reached about 700, the operation on the kill floor changed dramatically because a second kill line was opened. The rated capacity of the two lines are 660 hogs/hr and 330 hogs/hr. The average production shift was defined on the basis of one line, the larger of the two, being used with a kill of 1,438,135 lb/day (652,340 kg/day).

This average shift was used to estimate total wastewater use and total pollutant discharge on an average day as follows. An average flow rate for the process or sampling station of interest was identified. The flow rate was constant throughout the production period regardless of the number of hogs processed with two exceptions: the hasher-washer drain and the neck washer. The flow for the average production shift was calculated from the average flow rate during the 7.79 hr/shift.

For example, the value for the blood conveyor wash was calculated using the average flow rate of 5.71 gal./min: 2668 gal./shift = (7.79 hr/shift) x (60 min/hr) x (5.71 gal./min) = 10,100 l/shift.

The flow rate expressed as gal./1000 lbs live weight killed, shown as (LWK), is simply the flow for the average production shift divided by the weight of hogs killed on an average production shift. For example, the value for the

Table 4. FLOW MEASUREMENT AND WASTEWATER SAMPLING METHODS USED DURING THE PRODUCTION SHIFT

Sampling location	Sampling method	Flow measurement
Bleed floor drain	No discharge	No discharge
Bleed area floor drain	No discharge	No discharge
Bleed conveyor wash	Automated grab[a]	Time known volume
Scald tank	Manual short-term composite[b]	No flow[c]
Defeather floor drain	Automated grab[a]	Totalizing flow meters in water supply lines
Bailpolisher	Automated grab	Totalizing flow meter
Carcass shower	Automated grab	Totalizing flow meter
Feather-washer drain	Manual short-term composite	Lithium dilution
Stomach washer	Manual short-term composite	Lithium dilution
Neck washer	Manual short-term composite	Time known volume
Head washer	Manual short-term composite	Time known volume
NW grease drain	Automated grab	Lithium dilution
Center grease drain	Automated grab	Lithium dilution
SW grease drain	Automated grab	Lithium dilution

[a] ISCO automated sampler.
[b] Five to six grabs composited over 5 to 10 minutes.
[c] One inch diameter rubber bladder valve with compressed air supply controlled by a solenoid.
[d] Samples were from the scald tank which is dumped during cleanup.

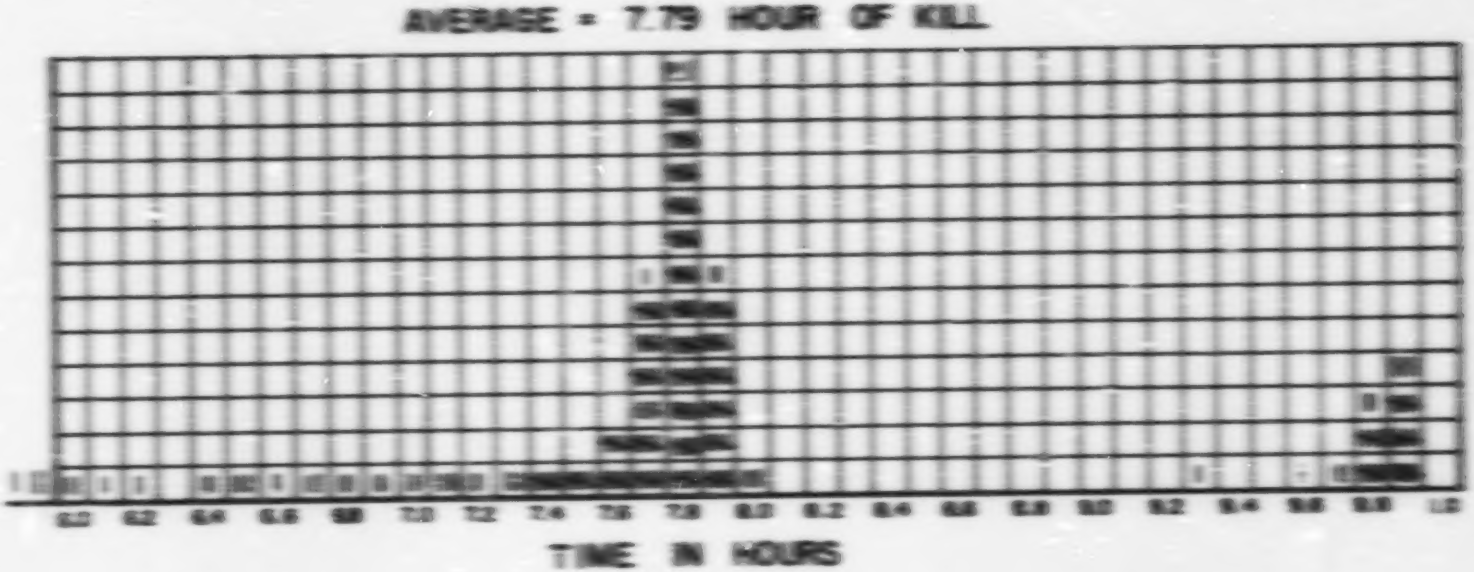


Figure 21. Histogram showing length of production [illegible].

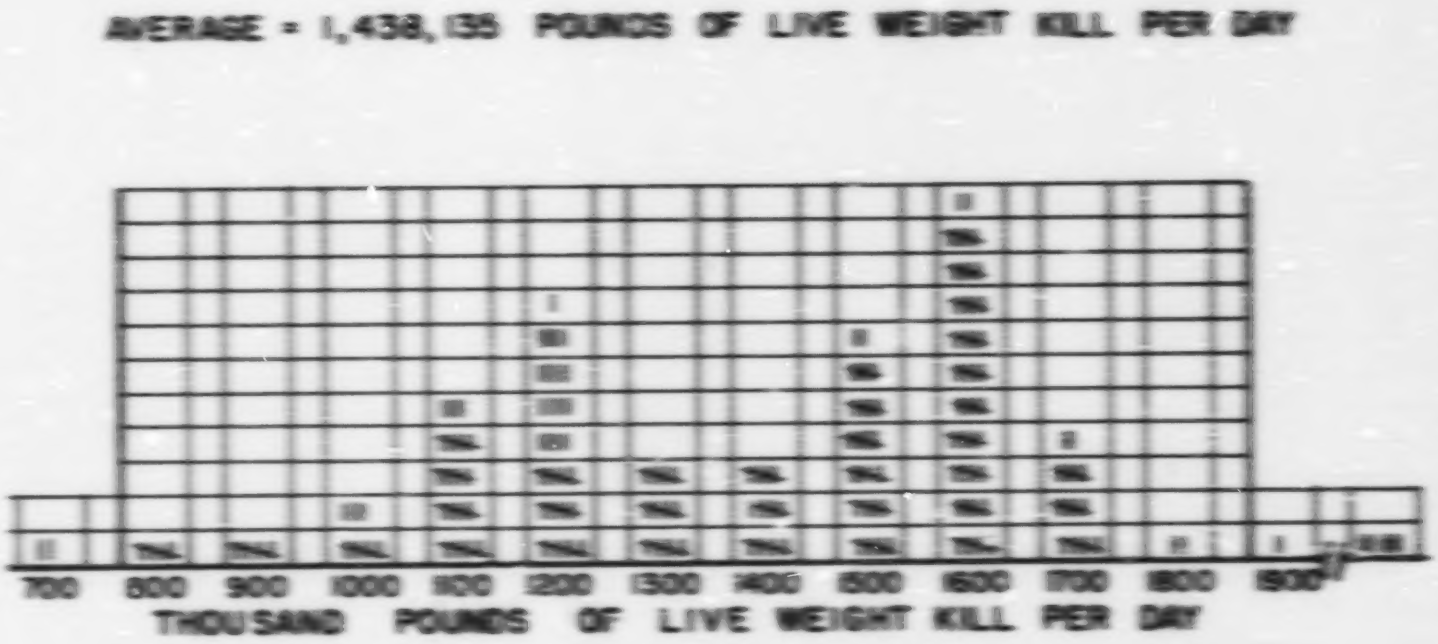


Figure 24. Histogram of pounds of live weight hogs killed per production shift.

bleed conveyor wash was calculated as:

$$\frac{2668 \text{ gal/shift}}{1438.135 \text{ 1000 lb LWK/shift}} = 1.9 \text{ gal/1000 lb LWK}$$

See Table 6. In Standard International units this is 15.9 l/1000 kg LWK.

The pollutant loads are calculated in similar fashion. In most cases there is no clear relationship of concentration with the number of hogs being processed. This point will be discussed more carefully in connection with specific processes later. The data at each sampling location was analysed to identify either the average concentration during the day or the actual kilograms of pollutant discharged during the day. These numbers are consistent with the flow per production shift used, that is, the average flow multiplied by the average concentration gives the mass discharged during an average production shift.

For example, the bleed conveyor wash BOD load is: 20.5 lb BOD/shift = (920 mg BOD/l) x (2668 gal./shift) x(3.78 l/gal.) x (2.2 lb/ kg) x(10^{-6} kg/mg). Also 20.5 lb BOD/shift ÷ 2.2 lb /kg = 9.3 kg BOD/shift.

The ratio of BOD to live weight of hogs killed is calculated using the average weight of hogs killed on an average production shift. For the bleed conveyor wash the calculation was 20.5 lb BOD/1438.135 1000 lb LWK = 0.014 lb BOD/1000 lb LWK. This is a mass per mass ratio and the numerical value is the same for pounds or kilograms, i.e., 0.014 lb BOD/1000 lb LWK = 0.014 kg BOD/1000 kg LWK. This value is shown in Table 6.

DISCUSSION

The production shift discharge is 350,700 gal. of wastewater (1,327,540 l) which is 244 gal./1000 lb of LWK (2032 l/1000 kg LWK). To be consistent with industry tradition, to simplify the data presentation, and to focus on the major pollution areas, the flows and loads from the various sample points are presented as a percentage of the totals in Table 5. Table 6 summarizes the results as mass/1000 mass units LWK. Table 6 is a summary of the detailed data tables presented in Appendix A.

The objective of the characterization study was to pinpoint processes and drainage points that were the main contributors to the pollution problems. Table 5 will be discussed point-by-point to explain the relative role of the various sample points in the overall pollution problem on the production shift.

Bleed Area

There was insignificant discharge from the bleed area floor drain during the production shift. This location will receive greater attention in Chapter VI in the cleanup discussion. Bleed conveyor blood drain sample point had no discharge during the production shift. It also will be discussed in the cleanup chapter. The flow from the bleed conveyor wash drain is constant during the

Table 5. [illegible]

(percent)

Sample point	Flow	Total solids	Total volatile solids	Suspended solids	Volatile suspended solids	Grease	Total Kjeldahl nitrogen	BOD	COD
Blood area floor drain	No flow	—	—	—	—	—	—	—	—
Blood conveyor blood drain	No flow	—	—	—	—	—	—	—	—
Blood conveyor wash drain	0.9	5.5	0.5	0.1	0.1	0.1	0.8	0.4	0.4
Dehair floor drain + scald tank	20.8	16.6	15.8	17.8	18.1	3.4	20.4	13.2	22.8
[illegible]	3.6	0.7	0.5	0.1	1.1	-	0.4	0.2	0.2
[illegible] drain	3.6	0.9	0.7	0.2	0.3	0.1	0.8	0.5	0.4
"WS" grease drain	9.8	1.9	1.2	0.6	0.6	0.2	3.5	1.8	0.8
Intestine shower	(0.2)	(1.3)	(0.7)	(0.1)	(0.1)	-	(1.5)	(0.2)	(0.3)
Center grease drain	5.9	1.2	1.1	0.3	0.8	0.1	0.6	0.6	1.1
"IR" grease drain	6.7	5.0	3.8	2.2	2.5	1.4	10.4	4.2	3.8
Head washer	(1.8)	-	-	-	-	-	-	-	-
Stomach washer drain	29.9	13.1	14.3	17.5	18.9	27.1	7.6	13.1	14.7
[illegible] washer drain	21.8	59.2	63.9	61.4	58.5	67.4	43.5	66.8	56.4
Neck washer	(3.5)	(11.9)	(16.9)	(12.8)	(13.8)	(28.5)	(6.6)	(8.9)	(9.5)
Total %	100	100	100	100	100	100	100	100	100
Gal/batch	[illegible]	—	—	—	—	—	—	—	—
Liters/batch	[illegible]	—	—	—	—	—	—	—	—
Gal/1000 lb LWK	246	—	—	—	—	—	—	—	—
Liters/1000 kg LWK	2053	—	—	—	—	—	—	—	—
lbs/batch		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	770	[illegible]	[illegible]
kg/batch		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	350	[illegible]	[illegible]
lbs/1000 lb LWK		7.4	5.8	3.8	3.2	5.32	0.5	4.0	10.2
kg/1000 kg LWK		7.4	5.8	3.8	3.2	5.32	0.5	4.0	10.2

[a] Values in parentheses are a subset of the preceding values and are not included in the totals.

Table 4. [illegible]
([illegible])

Sample point	Flow	Total solids	Total volatile solids	Suspended solids	Total suspended solids	Grease	Total Kjeldahl nitrogen	BOD	COD
Blood area floor drain	-	-	-	-	-	-	-	-	-
Blood conveyor blood drain	-	-	-	-	-	-	-	-	-
Blood conveyor wash drain	1.9	0.036	0.030	0.006	0.003	0.002	0.004	2.014	0.036
Dehair floor drain + scald tank	70.1	1.225	0.075	0.649	0.586	0.188	0.131	.55	7.288
Rosin stripper	0.6	0.054	0.029	0.005	3.004	0	0.002	0.007	0.021
Hog polisher drain	0.9	0.069	0.040	0.339	0.009	0.005	3.095	0.023	0.045
"WH" grease drain	21.9	0.136	0.070	0.021	0.018	0.012	0.019	0.417	0.096
Carcass shower^a	(72.1)	(0.092)	(0.036)	(0.004)	(0.004)	-	(0.008)	(0.210)	(0.030)
Cooler grease drain	24.1	0.088	0.077	0.033	0.029	0.088	0.045	0.025	0.227
"CB" grease drain	26.1	0.438	0.275	0.086	0.080	0.074	0.036	0.199	0.388
Head washer^b	(4.5)	-	-	-	-	-	-	-	-
Stomach washer drain	48.5	0.981	0.827	0.671	0.606	1.454	0.261	0.537	1.388
Tripe washer drain	53.2	4.348	3.738	2.346	1.899	3.590	0.238	2.788	6.888
Neck washer^c	(8.6)	(1.820)	(0.581)	(0.472)	(0.460)	(1.564)	(0.020)	(0.367)	(0.900)
Total gallons/1000 lb LWK	204.1	—	—	—	—	—	—	—	—
Total pounds/1000 lb LWK	—	7.36	5.66	3.830	3.228	5.325	0.533	4.267	20.227

^a Carcass shower is included in WH grease drain totals.

^b Head water is included in CB grease drain totals.

^c Neck water is included in tripe-washer drain totals.

production shift and is only 0.8%. This indicated that extensive efforts to reduce or eliminate this flow could prove uneconomical.

Dehair and Scald Tank

During the production shift there is no discharge from the scald tank; discharge during cleanup is considered in the next chapter. The dehair floor drain is the largest single flow contributor during the production shift. This drain constitutes 28.8% of the total production flow. This discharge point obviously should receive a great deal of attention in the reduction and change portion of the study. The pollution loadings are also a major percentage of the total load from the production shift. The drain contributes 16.6% of the total solids during the production shift, and 24.4% of the total Kjeldahl nitrogen. The BOD and COD contributions from the drain are also a significant percentage of the total. Chapter VIII discusses the types of changes that can be made to the dehairing machine operation to reduce the high flow and pollution contributions.

Although the rosin stripper is responsible for 3.6% of the production flow, it produces only 0.7% of the total solids of the production shift. This piece of equipment uses 8.6 gal./1000 lb LWK, but this water is used mainly for lubrication and hardening in the rosin stripper and does not receive large concentrations of solids or BOD before it enters the drain.

The railpolisher is responsible for 3.6% of the flow, 0.9% of the total solids, and 0.5% of the BOD during the production shift. The water is mainly used for lubricating the hogs and does not receive high concentrations of solids and BOD before entering the drainage system.

Grease Drains and Carcass Shower

The 660 grease drain, which includes the carcass shower, contributes 9% of the flow, but only 1% of the BOD from the production shift. The majority of the flow comes from the carcass shower.

Efforts should be directed toward volume reduction with attention being given to carcass cleaning. The center grease drain has flow only when both slaughter lines are running and the main contribution is a second carcass shower. This drain produces 5.9% of the production flow, but only 0.6% of the production BOD. This drain is similar to the 660 grease drain and offers the same potential for reduction.

The 330 grease drain and head washer contributed 6.7% of the flow on the production shift. This is 16.4 gal./1000 lb LWK, of which 4.5 gal./1000 lb LWK are from the head washer. This drain differs from the 660 grease drain and the center grease drain in that it also has significant concentrations of solids, nitrogen, and BOD. This grease drain covers almost two-thirds of the kill floor and during production, receives organic solids from the carcass splitting area and the evisceration treadmill area. This drain is responsible for 10.4% of the total Kjeldahl nitrogen and, thus, any attempts to reduce nitrogen should include attention to this drain.

Stomach Washer

The stomach washer drain contributed 19.9% of the flow, 13.3% of the total solids, 13.3% of the BOD, but only 7.6% of the total Kjeldahl nitrogen of the production shift. This indicated that the large volumes of water are coming in direct contact with organic solids. These organic solids are undigested food that contain a low nitrogen content. A large percentage of the total solids are suspended solids and almost all of the suspended solids were volatile. This suggested changes that could prove valuable for this particular piece of equipment.

Hasher-Washer Drain

Although the hasher-washer drain contributed 21.8% of the flow of the production shift, it contributed 59% of the total solids and 66.8% of the BOD. This drain was by far the largest contributor to the pollution load of the production shift; it contributed more pounds of BOD per production shift than all of the others combined. Therefore, any successful reduction of the pollution load from this drain will be a significant reduction in total load from the production shift.

CONCLUSION

This wastewater characterization of the production shift has identified those areas and processes that are the largest contributors to the flow and pollution load. The hasher-washer is the main polluter, followed by the dehairing machine.

SECTION VI

CHARACTERIZATION OF THE CLEANUP SHIFT

INTRODUCTION

General Cleanup Procedures

The main cleanup shift begins immediately after the production shift, and lasts approximately 6 hr. There are two mid-shift cleanups and a more complete cleanup during the lunch break. These partial cleanups were characterized as part of the pollution load from the production shift. The majority of the pollution load from the cleanup shift is discharged within the first hour. The most important production related influence would be the operation of two kill lines, thus requiring two sets of evisceration equipment to be cleaned and adding the general floor area around the second kill line to the normal load.

Cleanup Equipment and Timing

The basic tool used for cleanup was the high pressure hose (60 - 80 psi). Hosing is preceded by a broom and shovel dry cleanup. The major accumulation of solids should be shoveled into containers for inedible processing rather than being pushed and washed down the sewer drains. It was often difficult to enforce good drycleaning procedures, but they are an essential part of any well-organized pollution reduction program. A vacuum technique was implemented on this project to increase the amount of dry cleaning on the mid-shift and final cleanups. This idea will be discussed with other changes in Section VIII.

Several pieces of equipment are cleaned by turning on internal water sprays to full capacity while personnel are performing other cleanup procedures. In particular, the viscera pans, treadmill, and stomach washer were cleaned with this technique. The first 30 min of rinsing washed the majority of the contaminates off the equipment, but the water was often left running at full capacity for 3 to 4 hr. This waste of potable water accomplished little additional cleaning, and was quantified in this study.

During the cleanup shift the blood recovery drains are plugged and all wastes enter the greasewater drains. The stick-and-bleed area was the largest contributor of blood pollution on the cleanup shift. Dry cleaning of this area has been suggested, but it has not been carried out consistently. Dry cleaning with high pressure air was studied at the Beardstown Plant in an attempt to increase the amount of blood recovered and to minimize the addition of the pollution load. However, OSHA regulations prohibit using the high pressures (above 30 psi) required to be effective.

WASTEWATER FLOW MEASUREMENTS

Quantification of the flows on the cleanup shift and establishment of correlations between flows and concentrations of pollutants were difficult. The flow measurement techniques used were meters, bucket-and-stopwatch, and lithium chloride dilution techniques. Meters were used whenever possible and readings were taken before and after the cleanup shift. As in the production shift many areas were not suitable for metering due to plumbing complexities and cost and time constraints. Flow measurement in the grease drains was difficult due to high flow variability (at times the flow approached zero). This made it difficult to use the lithium chloride technique which depends on sufficient quantities of water to insure adequate mixing and dilution.

WASTEWATER SAMPLING METHODS

The cleanup shift offered sampling problems similar to those of the production shift. The low flow problem was partially solved by having an ISCO sampler pump continuously collect a volume of water over a 15 min period in a single large container. This container was mixed and a 500 ml sample was taken.

Sampling the cleanup period was also complicated by the large flush that occurs during the first 30 to 60 min. Adequate sampling during this initial period is critical for correct estimation of the pollution load. The heavy load carried by this first flush can clog the automatic sampler. In many cases only grab sampling was used. Often manual sampling was used to compliment the automatic sampler during the first flush. During the first flush, the sampling frequency was usually 6 to 12 samples/hr. Sampling problems encountered at particular stations will be discussed in detail in the wastewater sampling station section.

WASTEWATER SAMPLING STATIONS

Sampling points in the production section are shown on the kill floor plan (Figure 22 in Section V). The nature of the cleanup operation tended to eliminate a process-by-process breakdown of the pollution load. The discharges from the various pieces of equipment during cleanup were difficult to trace, but processes were isolated for characterization on the cleanup shift whenever possible.

Bleed Area Floor Drain

During cleanup the bleed area floor drain collects waste from the stick-and-bleed conveyor area and discharges into the plant grease drain system. The first flush was very high in BOD and TKN due to blood spills from the production shift. Manual sampling of this drain was required. Sample frequency was increased during the first hour to insure accurate representation of the first flush which is approximately 80% of the total pollution load from the cleanup shift.

Flow into this drain during cleanup was from cleanup hoses used on the bleed conveyor and the general stick-and-bleed area. The total flow was estimated by timing the use of each hose and multiplying by the flow rate of the hose. The flow rate of the hose was determined by the bucket-and-stop-watch technique. The total hose flow was split between this drain and the bleed conveyor blood drain.

Bleed Conveyor Blood Drain

During the cleanup shift the bleed conveyor blood drain collected water used to clean the bleed trough and discharges into the plant grease drain system. Dry cleaning of the blood trough before hosing can increase the amount of blood recovered and reduce the pollution load. When blood recovery was ended this drain was switched from the blood recovery system to the grease drainage system. The first flush was still very high in blood and solids. Flow was estimated based on the cleanup hose flow in the bleed area that entered the blood drain. Frequent grab samples were collected as the waste bypassed the blood recovery pump and entered the grease drainage system.

Bleed Conveyor Wash Drain

During the cleanup shift the bleed-conveyor-wash drain collected water from the rinse nozzle on the bleed conveyor and discharged into the plant grease water drainage system. The drain was sampled just below the conveyor with the ISCO automatic sampler. The flow rate was constant from the spray nozzles during cleanup and was measured with the bucket-and-stopwatch technique.

Dehair Floor Drain and Scald Tank

During the cleanup shift the dehair floor drain collected wastewater from the dehairing machine and the scald tank and discharged this waste into the manure wastewater system. This drain was sampled as described in the production section. Due to the hair clogging problem, manual sampling was necessary. The flow meters on the dehairing machine were read before and after cleanup. To this was added the volume of the scald tank water (8,000 gallons) which entered the dehair drain.

Rosin Stripper Shower

During cleanup the rosin stripper spray was shut off. A negligible amount of water was used to clean the rosin stripper.

Railpolisher Drain

The railpolisher spray should not be on during cleanup. Nevertheless, some cleanup personnel did turn on the railpolisher sprays during cleanup. This wasted thousands of gallons of water and did not improve the quality of the cleanup. Proper cleanup, using only a hose, should result in a negligible total flow from this drain during cleanup.

The 660 Grease Drain

During the cleanup shift the 660 grease drain collected wastewater from the south end of the kill floor and from the 660 line carcass shower. Several lavatories, sprays, and floor drains on the south end of the kill floor discharge into the 660 grease drain system. This drain was sampled with the automatic sampler through a clean-out port one floor below the kill floor. The flow was measured using the lithium chloride technique.

Carcass Shower Drain

During the cleanup shift the carcass shower drain collected water used to clean several areas and discharges the water into the 660 grease drain. Since the carcass shower itself was not on during cleanup the only flow is from cleanup hoses.

Center Grease Drain

During the cleanup shift the center grease drain collected water used to clean the 330 carcass shower and surrounding area. This drain was sampled by pumping continuously with an automatic sampler to make up 15 min composite samples. The lithium chloride technique was used to measure flow. The flow and load samples were collected through a clean-out port on the floor below. The flow in this drain for the cleanup shift was negligible during the sampling program.

330 Grease Drain

Normally production used only the 660 hog/hr line. During the cleanup shift the 330 grease drain collected water from the north half of the kill floor and discharged this flow into the plant greasewater system. These flows are a total of the hose discharges used to clean the equipment on this end of the kill floor. When the 330 hog/hr kill line has been used, more flow is measured due to the cleaning of the additional pieces of equipment. This drain was sampled both automatically and manually through a clean-out port from the floor below. The flow was measured with the lithium chloride technique. There were periods of no flow to this drain.

Head Washer

The head washer did not operate during cleanup. Any wastewater from cleaning the equipment is included in the 330 grease drain.

Stomach Washer Drain

During the cleanup shift the stomach washer drain collected water used to clean the stomach washer and slitter-dumper. This discharges into the manure wastewater system. Some of the water used to clean the tumble washer spills onto the floor and enters the 660 grease drain. This drain was sampled by the same manual dip technique described for the production shift. Flow measurement was by the lithium chloride technique as described for the production shift.

Hasher-Washer Drain

During the cleanup shift, the hasher-washer drain collected water used to clean the viscera pans, the evisceration treadmill, and the neck washing area. The first flush from this cleanup operation was very high in blood and fatty solids. Dry cleaning must precede hosing to reduce blood and solids entering this drain. This drain was sampled from one floor below at the hasher-washer. Samples were collected as described in the production section, and the flow was measured using the lithium chloride technique.

Neck Washer Drain

During cleanup, the neck washer drain collected water used to clean the neck washing area and discharged into the hasher-washer drain. This wastewater was included in the hasher-washer drain cleanup total.

WASTEWATER CHARACTERIZATION

Characterization of the cleanup shift was complicated by the variability of discharges, both flow and concentration. The first flush at each sampling point represented the majority of waste for the entire cleanup shift. After the first high concentration flush, the cleanup waters generally had very low concentrations with varying flows.

The total load of pollutants for the cleanup shift was not dependent on the production rate except when the second kill line was used. Approximately the same volumes of water are used to clean the equipment independent of the duration of production or the rate of production. The flow and concentration values were based on the flow measurement and sampling techniques described in the previous chapters. Due to the high variability, the total cleanup shift flow for a particular sample point was found by summing the discharges over several short-time periods (ΔT). The total flow is:

$$\frac{\text{gal.}}{\text{shift}} = (\Delta T,\ \text{min}) * (\text{Avg flow, gpm})$$

This value was then converted to gal./1000 lb LWK by dividing by the pounds of hogs killed on the average day:

$$\frac{\text{gal.}}{\text{1000 lb LWK}} = \frac{\text{gal./shift}}{\text{1438.136 (1000 lb LWK/shift)}}$$

For example, the 330 grease drain has the cleanup shift flow profile shown graphically in Figure 25 and tabulated in Table 7. Summing the incremental flow values gives the 330 grease drain discharge of 16,405 gallons of wastewater per cleanup shift. This was converted to gal./1000 lb LWK as follows:

$$\frac{\text{16,405 gal./shift}}{\text{1438.136 (1000 lb LWK shift)}} = \text{11.40 gal./1000 lb LWK}$$

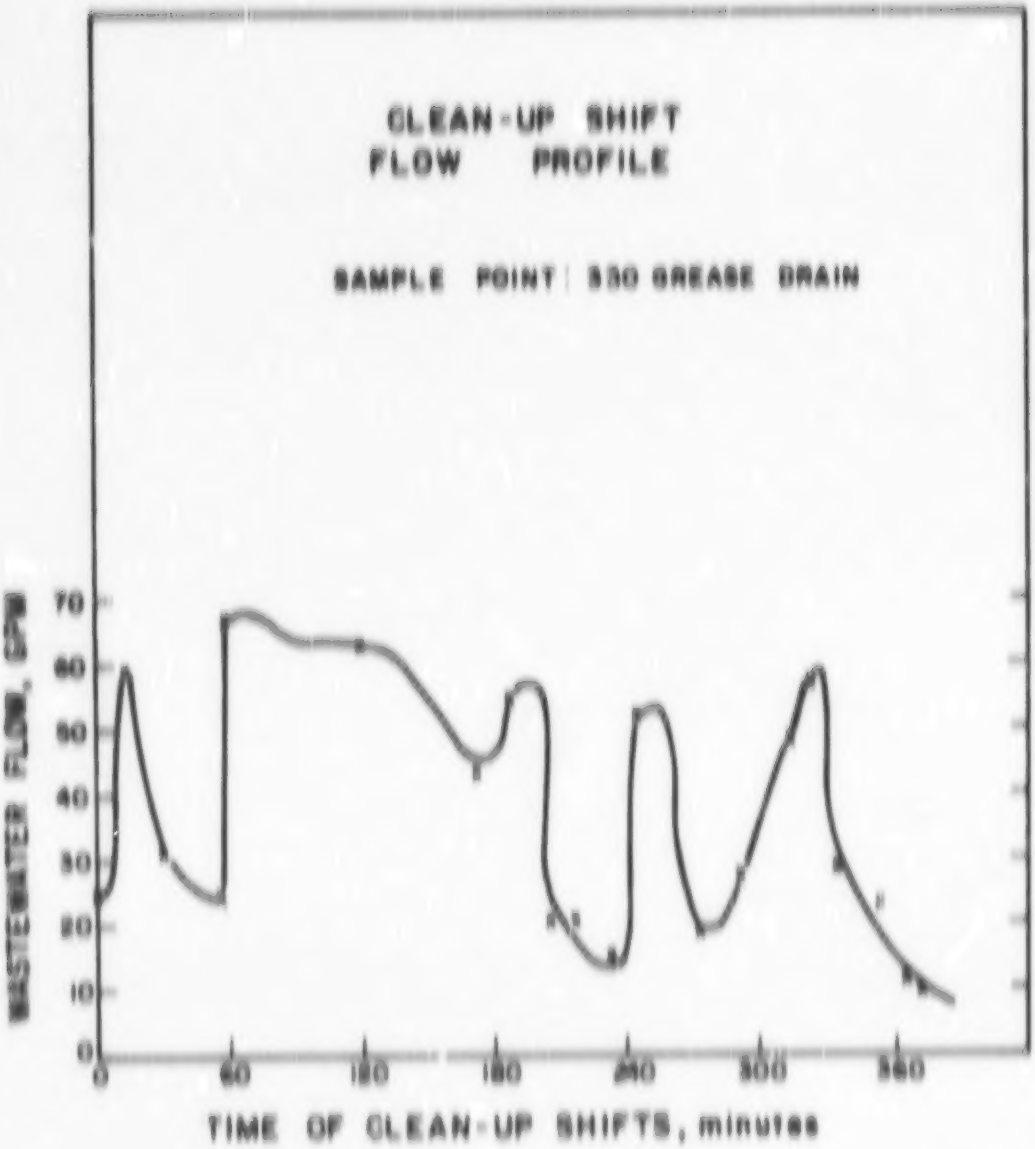


Figure 25. Cleanup shift flow profile (330 hog/hr grease drain).

TABLE 7.

TYPICAL CLEAN-UP SHIFT FLOW PROFILE AND SAMPLE TOTAL FLOW CALCULATION

Sample Point: 330 Grease Drain

Min. from start of cleanup	Time	ΔT (Min.)	GPM	Sum of total gallons
0 - 10	2:40 - 2:50 PM	10	25	250
10 - 30	2:50 - 3:10	20	59	1180
30 - 50	3:10 - 3:30	20	31	620
50 - 60	3:30 - 3:40	10	24	240
60 - 105	3:40 - 4:25	45	67	3015
105 - 120	4:25 - 4:40	15	63	945
120 - 170	4:40 - 5:30	50	63	3150
170 - 190	5:30 - 5:50	20	43	860
190 - 200	5:50 - 6:00	10	55	550
200 - 215	6:00 - 6:15	15	20	300
215 - 230	6:15 - 6:30	15	20	300
230 - 245	6:30 - 6:45	15	15	225
245 - 275	6:45 - 7:15	30	52	1560
275 - 290	7:15 - 7:30	15	19	285
290 - 320	7:30 - 8:00	30	27	810
320 - 335	8:00 - 8:15	15	57	855
335 - 350	8:15 - 8:30	15	29	435
350 - 365	8:30 - 8:45	15	23	345
365 - 380	8:45 - 9:00	15	12	180
380 - 410	9:00 - 9:30	30	10	300
				16,405

This value is shown in Table 10. In Appendix B, the complete cleanup shift data tables are shown also in SI units:

16,405 gal./shift x 3.78 l/gal. = 62,000 l/shift and

$$\frac{62,000 \text{ l/shift}}{652.340 \text{ (1000 kg LWK/shift)}} = 95.0 \text{ l/1000 kg LWK}$$

The cleanup shift produces an average of 137,540 gallons of wastewater (521,640 l) per shift, which is 95.6 gal./1000 lb LWK.

To be consistant with industry tradition, to simplify data presentation, and to focus on the major pollution areas, the cleanup flows from the various sample points are presented as a percentage of the cleanup total in Table 9, and per 1000 lb LWK in Table 10, which is a summary of the detailed data table presented in Appendix B.

The total pounds (kilograms) of pollutants, BOD for example, per cleanup shift was found by summing short time periods (ΔT) multiplied by the incremental BOD concentration of that time period, the incremental flow for that period, and a conversion constant.

$$\text{BOD/shift} = (\Delta T, \text{min}) (\text{mg/l BOD}) (\text{flow, gpm}) (8.34/10^6)$$

This value was converted to lb/1000 lb LWK by dividing by the average lb of hogs killed on an average day.

$$\text{lb of BOD/1000 lb LWK} = \frac{\text{lb of BOD/shift}}{1438.138 \text{ (1000 lb LWK/shift)}}$$

For the 330 grease drain these calculations are shown in Table 8 and the incremental BOD concentrations are plotted in Figure 26. Summing the incremental BOD values gives the 330 grease drain discharge of 65.70 lb BOD on an average shift which is converted to lb BOD/1000 lb LWK:

$$\frac{65.7 \text{ lb/shift}}{1438.138 \text{ (1000 lb LWK/shift)}} = 0.046 \text{ lb of BOD/1000 lb LWK}$$

This value is shown in Table 10 and in the complete cleanup shift data given in Appendix B. In Appendix B this value is converted into SI units as:

65.7 lb/shift x 0.4536 kg/lb = 29.80 kg/shift and 0.046 kg of BOD/1000 kg LWK

The total cleanup shift produced 0.219 lb BOD/1000 lb LWK. Simillar calulations produced the other total cleanup pollutant loads (Table 10).

TABLE 8

EXAMPLE OF POLLUTANT LOAD CALCULATION FOR THE CLEAN-UP SHIFT

Sample Point: 330 Grease Drain

ΔT (Min.)	BOD mg/l	GPM Flow	Constant		Total pounds of BOD
10	1112	25	8.34/10^6	=	2.318
20	2318	59	8.34/10	=	22.81
20	960	31	8.34/10	=	4.96
10	392	24	8.34/10	=	.78
45	399	67	8.34/10	=	10.03
15	102	63	8.34/10	=	.80
50	341	63	8.34/10	=	8.96
20	968	43	8.34/10	=	6.94
10	857	55	8.34/10	=	3.93
15	66	20	8.34/10	=	.16
15	132	10	8.34/10	=	.33
15	275	15	8.34/10	=	.51
30	178	53	8.34/10	=	2.360
15	3	19	8.34/10	=	.001
30	3	27	8.34/10	=	.02
15	29	57	8.34/10	=	.208
15	61	27	8.34/10	=	.206
15	125	23	8.34/10	=	.36
15	83	12	8.34/10	=	.12
30	58	10	8.34/10	=	.145
					65.9

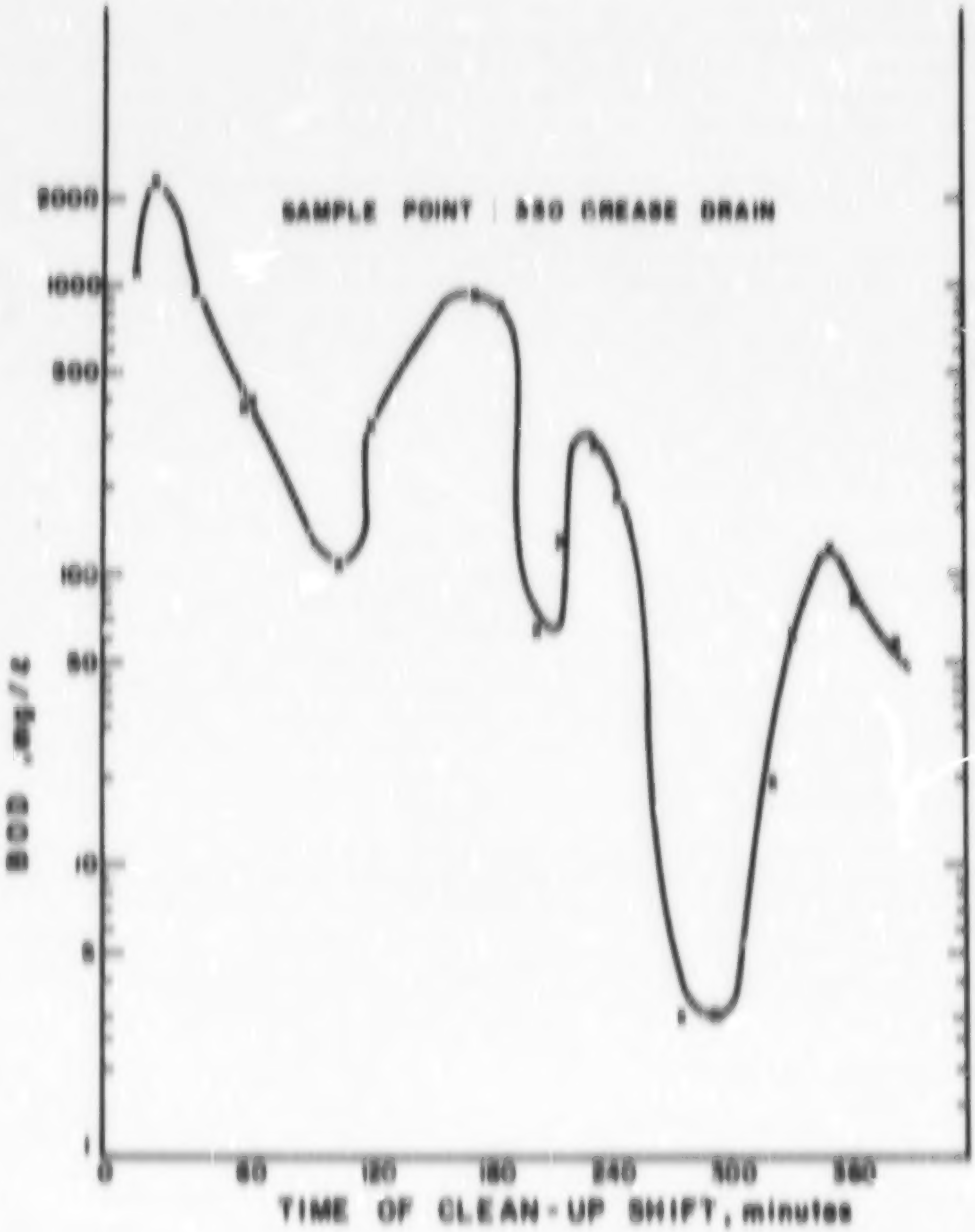


Figure 26. Cleanup shift BOD$_5$ concentration profile.

DATA SUMMARY

The variability of the samples collected on the cleanup shift was due to the unpredictable nature of the first flush and the difficulty in analyzing samples with very high solids and BOD values. Large numbers of samples were taken, when possible, to increase the statistic validity of the data. Data was collected on many different days with various cleanup crews to obtain some idea of the inherent variability of the cleanup shift. If data was collected on several days, an average of the days flow and pollutant loads was used to produce the value in Table 10.

As previously mentioned, to be consistant with industry notation, to simplify the data presentation, and to focus on the major pollution areas, the cleanup flow and pollutant loads from the various sample points are presented as a percentage of the cleanup total in Table 9, and per 1000 lb LWK in Table 10. Since the objective of the characterization study was to pinpoint processes and drainage points that were the main contributors to the pollution problem, Table 9 will be discussed point-by-point to explain the selective role of the various sample points in the overall pollution problems on the cleanup shift.

Bleed Area Floor Drain

The bleed area floor drain contributes 1.6% of the flow, 0.9% of the total solids, 7.5% of the BOD and 16.0% of the total Kjeldahl nitrogen of the cleanup shift. This indicates a higher than average concentration of Kjeldahl nitrogen. This is due to raw blood being washed down this drain during the cleanup shift. Cleanup personnel used large volumes of water to move the blood to the floor drain. This was necessary because the drain was confined so the cleanup man had no access to dry clean the surrounding floor. Improvements are needed.

Bleed Conveyor Blood Drain

The bleed conveyor blood drain contributed only 0.7% of the flow, 0.4% of the total solids, 2.1% of the BOD, and 3.6% of the total Kjeldahl nitrogen of the cleanup shift. This was a small volume of water with a high level of nitrogen. The blood that did not go to the recycle system ends up in the blood drain. Due to the construction, clots of blood built up on the trough, and hand cleaning was necessary. The levels of nitrogen can be reduced by manual cleaning techniques.

Bleed Conveyor Wash Drain

The bleed conveyor wash drain was constantly flowing during the cleanup shift. The 5.71 gpm (mean value) of flow rinses the bleed chain and produces a high concentration of nitrogen due to the blood. The total flow from this drain was only 1.3% of the total cleanup flow and received minor attention during the cleanup modification stage.

Dehair Floor Drain and Scald Tank

The scald tank is drained into the dehair floor drain for the first hour

Table [illegible]

(percent)

Sample point	Flow	Total solids	Total volatile solids	Suspended solids	Volatile suspended solids	Grease	Total Kjeldahl nitrogen	BOD-5	COD
Blood area floor drain	1.6	0.9	4.0	2.2	3.2	9.6	16.0	7.5	4.9
Blood conveyor blood drain	0.7	0.4	2.4	0.9	1.3	1.2	3.6	2.1	2.7
Blood conveyor wash drain	1.3	0.6	1.6	0.6	0.5	0.3	1.9	0.6	1.8
Rehair floor drain	55.6	15.2	55.2	56.7	60.9	21.6	62.6	57.2	66.2
Scald tank	(6.2)[d]	(6.5)	(22.5)	(29.4)	(22.6)	(9.2)	(58.6)	(26.9)	(27.7)
Hair stripper shower	_[a]	-	-	-	-	-	-	-	-
Nail polisher drain	_[b]	-	-	-	-	-	-	-	-
"WR" grease drain	7.1	3.7	6.9	4.6	4.6	10.2	8.2	6.5	7.9
Carcass shower	_[a]	-	-	-	-	-	-	-	-
Central grease drain	_[c]	-	-	-	-	-	-	-	-
"OR" grease drain + bowl water	9.6	75.6	18.9	26.6	22.6	45.2	3.9	20.3	12.1
Stomach washer drain	1.6	0.6	2.1	1.5	2.6	6.8	0.5	2.3	2.8
Gut washer drain	20.9	3.2	8.8	7.5	5.9	5.7	6.6	3.1	3.8
Total %	100	100	100	100	100	100	100	100	100
Gallons/shift	170760	—	—	—	—	—	—	—	—
Liters/shift	646370	—	—	—	—	—	—	—	—
Gallons/1000 lbs LWK	120.7	—	—	—	—	—	—	—	—
Liters/1000 kg LWK	1006.6	—	—	—	—	—	—	—	—
Pounds/shift	—	4785	677.0	626.1	349.4	146.1	36.4	314.6	820.6
Kilograms/shift	—	2161	307.0	284.2	158.5	66.1	16.5	142.7	371.6
Pounds/1000 lbs LWK	—	3.31	0.472	0.435	0.243	0.102	0.026	0.229	0.560
Kilograms/1000 kg LWK	—	3.31	0.472	0.435	0.243	0.102	0.026	0.229	0.560

[a] Included in "WR" grease drain total.

[b] Should have negligible flow during cleanup shift.

[c] No flow unless [illegible] kill line is cleaned.

[d] [illegible]

Table 18. TYPICAL WASTEWATER FLOW AND POLLUTION LOAD CHARACTERISTICS OF THE [illegible] DEPT.
(gal./1000 lb LWK and lb/1000 lb LWK)

Sample point	Flow	Total solids	Total volatile solids	Suspended solids	Total suspended solids	Grease	Total Kjeldahl nitrogen	BOD-5	COD
Blood area floor drain	1.9	0.031	0.023	0.009	0.008	0.009	0.064	0.026	0.028
Blood conveyor blood drain	2.0	0.025	0.011	0.004	0.003	0.001	0.001	0.005	0.013
Blood conveyor wash drain	1.5	0.019	0.008	0.002	0.001	0.001	0.0005	0.001	0.005
Hasher floor drain	66.3	0.596	0.268	0.262	0.140	0.022	0.016	0.125	0.377
Scald Tank	(5.6)	(0.216)	(0.156)	(0.106)	(0.052)	(0.009)	(0.015)	(0.030)	(0.150)
Hog stripper shower	–	–	–	–	–	–	–	–	–
Hair polisher drain	–	–	–	–	–	–	–	–	–
"HH" grease drain	8.7	0.126	0.032	0.019	0.011	0.010	0.002	0.014	0.045
Carcass shower [a]	–	–	–	–	–	–	–	–	–
Casing grease drain	–	–	–	–	–	–	–	–	–
"IIB" grease drain	11.4	2.488	0.089	0.115	0.052	0.366	0.002	0.066	0.060
Head washer [b]	–	–	–	–	–	–	–	–	–
Stomach washer drain	3.6	0.019	0.011	0.006	0.006	0.007	0.0001	0.005	0.011
Hasher washer drain	26.2	0.105	0.038	0.022	0.14	0.006	0.001	0.007	0.022
Neck washer [c]	–	–	–	–	–	–	–	–	–
Total flow gallons/1000 lb LWK	128.7								
Total lb of pollutant/1000 lb LWK		3.315	0.472	0.425	0.263	0.152	0.256	0.279	0.587

[a] Carcass shower is included in HH grease drain totals.

[b] Head washer is included in IIB grease drain totals.

[c] Neck washer is included in hasher-washer drain totals.

of the cleanup shift. The scald tank alone constitutes 4.2% of the flow, 58.8% of the total Kjeldahl nitrogen, and 26.9% of the BOD of the cleanup shift. This indicates that the 8,000 gal. (30,280 l) of wastewater in the scald tank had an unusually high concentration of total Kjeldahl nitrogen and should receive attention for potential modification since nitrogen has become a pressing pollution problem.

The combined dehair floor drain and scald tank discharges accounted for 55.6% of the flow and 57.9% of the BOD of the cleanup shift. This drain demands immediate attention to reduce both the total flow and the concentrations of pollutants that enter this drain during the cleanup shift.

660 Grease Drain and Carcass Shower

The 660 grease drain located on the south end of the kill floor received flow from the cleanup of the carcass shower area, the railpolisher area, and the gambreling area. The area is splashed with blood and small solids. Large volumes of water are used to clean this area because dry cleanup is difficult and time consuming. This drain is responsible for 7.9% of the total flow on the cleanup shift. This flow was not highly concentrated with pollutants, but it did contribute 6.3% of the BOD, 3.7% of the total solids, and 9.2% of the nitrogen of the cleanup shift.

330 Grease Drain

The 330 grease drain receives flow from two-thirds of the north end of the kill floor. Solids loads are high during the cleanup shift. Cleanup waters from the carcass splitting and treadmill areas enter the 330 grease drain. This drain accounted for 75.4% of cleanup total solids and low nitrogen content, but only contributed 20.9% of the BOD of the cleanup shift. The extremely high total solids load should be reduced. Several cleanup men work in this area and it is hard to identify the sources of all the water that are contributing to the pollution load.

Stomach Washer Drain

The tumble washer was cleaned by running circulating water through it. After the initial flush the concentration of pollutants was low. The internal water jets run for 0.5 to 3 hr. Cleanup of this equipment used only 3.0% of the water on the cleanup shift and 2.3% of the BOD.

Hasher Washer Drains and Neck Washer

The hasher washer drain contributed 20.9% of the flow, but only 3.1% of the BOD of the cleanup shift. This was due to the cleanup technique presently used which allowed all of the treadmill and viscera-pan sprays to run during the cleanup shift. This drain was the single largest contributor during the production shift and is a major contributor on the cleanup shift. Modification must be made in this area.

CONCLUSIONS

Predicting the total load from the kill floor cleanup for an average day requires a careful examination of the inherent variability due to the processes and personnel. The amount and quality of dry cleaning performed prior to hosing greatly affects the total quantity of pollution anticipated. A thorough dry cleaning program is very expensive due to high labor cost. Foremen insist that workers do not push the solids and blood down the drain, but this is hard to enforce.

This chapter has identified the dehair floor drain and the 330 grease drain as the high polluting areas on the cleanup shift. The previous chapter also identified these areas as high polluting areas on the production shift.

SECTION VII

CHARACTERIZATION OF THE TOTAL HOG-KILL FLOOR EFFLUENT

INTRODUCTION

This chapter presents the characterization of the combined hog-kill floor effluent from the production shift and the cleanup shift. This characterization consists of a summary of the data presented in Chapters V and VI. Certain sampling points such as the bleed area floor drain have no discharge during the production shift and therefore the total waste load from that sample point will be the same as the cleanup waste load. Each sample point's contribution is given in Table 11 as a percent of the total for each parameter measured. This is meant to pinpoint on a relative basis the major polluting areas of the kill floor and to minimize confusion with regard to units. A second table, Table 12, gives gal./1000 lb LWK and lbs of pollutant/1000 lb LWK. The complete data set is included in Appendix C.

WASTE WATER CHARACTERIZATION

The total flow and waste load summary will be discussed by sample point.

Bleed Area Floor Drain

The bleed area floor drain was not a major pollution contributor. This drain produced less than 0.7% of any pollutant observed. However, the potential by-product value of the blood which enters this drain is high and it should be kept out of this drain and put into the recovery system.

Bleed Conveyor Blood Drain

The bleed conveyor blood drain also was not a major pollutant contributor, producing only 0.2% of the total flow and less than 0.2% of any of the pollutants studied. As with the bleed area floor drain the value of the blood as a by-product makes improved recovery worthy of attention at this sample point.

Bleed Conveyor Wash Drain

This drain produced 0.9% of the total flow and 0.9% of the total Kjeldahl nitrogen, but less than 0.6% of any of the other pollutants. Efforts should be made to reduce the amount of water used for cleaning. At Davenport they have stopped washing the conveyor.

Table 11. TYPICAL WASTEWATER FLOW AND POLLUTION LOAD CHARACTERIZATION OF THE COMBINED CLEANUP AND PRODUCTION SHIFTS
(percent)

Sample point	Flow	Total solids	Total volatile solids	Suspended solids	Volatile suspended solids	Grease	Total Kjeldahl nitrogen	BOD	COD
Blood area floor drain	0.5	0.1	0.4	0.2	0.2	0.2	0.7	0.4	0.3
Blood conveyor blood drain	0.2	0.1	0.2	0.1	0.1	0.02	0.2	0.1	0.1
Blood conveyor wash drain	0.8	0.3	0.6	0.1	0.1	0.03	0.9	0.4	0.4
Dehair floor drain	27.6	16.2	18.3	21.8	22.1	1.7	26.1	15.5	15.6
Scald tank	(1.0)	–	–	–	–	(0.17)	–	–	–
Rosin stripper	2.4	0.5	0.6	0.1	0.1	–	4.6	0.2	0.3
Bell polisher drain	2.8	0.7	0.6	0.2	0.2	0.1	0.8	0.5	0.6
"HOG" grease drain	5.6	2.4	1.6	1.8	0.8	0.6	3.7	1.2	1.3
Carcass shower[a]	–	–	–	(0.1)	–	–	–	–	–
Center grease drain	2.9	0.8	1.2	0.8	0.9	0.1	0.9	0.6	3.1
"CUT" grease drain	7.7	27.6	6.2	4.7	3.8	2.2	18.1	3.8	1.9
Head washer[b]	–	–	–	–	–	–	–	–	–
Stomach washer drain	30.6	9.4	13.1	11.8	17.7	27.6	7.3	18.7	18.1
Gutter washer drain	21.6	41.7	58.7	55.5	56.8	68.3	41.8	63.6	63.1
Neck washer[c]	–	–	–	(0.3)	–	–	–	–	–
Total %	100	100	100	100	100	100	100	100	100
Gal/shift	57400								
Liters/shift	217250								
Gal/1000 lb LWK	382.7								
Liters/1000 kg LWK	325.7								
lb/shift		23565	9584	6125.7	4856	7802	808	6231.6	22960.7
kg/shift		6962.1	4217.0	2778.1	2267.0	3537.0	366.7	2762.5	7852.1
lb/1000 lb LWK		15.674	6.316	4.250	3.451	5.427	0.539	4.266	15.832
kg/1000 kg LWK		15.674	6.316	4.250	3.451	5.427	0.539	4.266	15.832

[a] Carcass shower is included in HOG grease drain totals.

[b] Head washer is included in CUT grease drain totals.

[c] Neck washer is included in gutter-washer drain totals.

Table 22. [illegible] CHARACTERISTICS OF THE [illegible] PRODUCTION UNITS
(gal/1000 lb LW and lb/1000 lb LW)

Sample point	Flow	Total solids	Total volatile solids	Suspended solids	Volatile suspended solids	Grease	Total Kjeldahl nitrogen	BOD	COD
Blood area floor drain	1.9	.031	.022	.029	.008	.003	.004	.014	.027
Blood conveyor blood drain	.8	.015	.011	.004	.003	.001	.001	.005	.013
Blood conveyor wash drain	1.4	.055	.038	.006	.004	.003	.005	.015	.042
Dehair floor drain	128.3	1.729	1.115	.996	.729	.212	.147	.461	1.485
Scald tank	–	–	–	–	–	–	–	–	–
Resin stripper	8.6	.174	.128	.065	.034	–	.002	.009	.023
Ball polisher drain	8.9	.269	.140	.059	.008	.005	.005	.020	.045
"ND" grease drain	31.6	.363	.102	.740	.029	.017	.021	.051	.135
Carcass shower[a]	(38.1)	(.892)	(.339)	(.354)	(.084)	(–)	(.008)	(.010)	(.030)
Cooler grease drain	14.3	.388	.077	.037	.029	.011	.005	.025	.377
"IS" grease drain	27.8	2.928	.264	.203	.132	.128	.057	.215	.360
Head water[b]	–	–	–	–	–	–	–	–	–
Stomach washer drain	52.1	1.080	.828	.677	.612	1.461	.061	.342	1.115
Washer water drain	78.2	4.445	3.768	2.376	1.894	3.396	.231	2.707	6.821
Neck water[c]	–	–	–	–	–	–	–	–	–
Total gallons/1000 lb LW	382.7								
Total lbs/1000 lb LW		15.674	6.324	4.259	7.651	5.427	.559	4.284	10.855

[a] Carcass shower is included in "ND" grease drain totals.

[b] Head water is included in "IS" grease drain totals.

[c] Neck water is included in washer-water drain totals.

Dehair Floor Drain and Scald Tank

The dehair floor drain was the largest contributor to the total flow of the kill floor; it accounts for 37.6% of the water used during the full day. The dehairing operation should receive a great deal of attention for water volume reduction. This sample point also accounts for 26.1% of the total Kjeldahl nitrogen and 15.5% of the BOD; it is the second largest contributor of these pollutants. Several changes can be made to reduce both the flow and waste load generated, as discussed in the next chapter.

Rosin Stripper

The rosin stripper contributes less than 1% of any of the pollutants, but it does account for 2.4% of the total flow. New nozzles and piping should be installed to reduce this flow during the production shift.

Railpolisher Drain

The railpolisher was very similar to the rosin stripper in flow and waste loads. The railpolisher contributed little of the total BOD and COD, but about 2.5% of the total flow. As with the rosin stripper flow reduction is the main problem to focus on for this sample point.

660 Grease Drain and Carcass Shower

The 660 grease drain was the fourth largest source of wastewater. The majority of the flow is produced on the production shift by the carcass shower. The carcass shower flow was 20.1 gal/1000 lb LWK out of the total of 30.6 gal./1000 lb LWK in the 660 grease drain (Table 12). However, the carcass shower was dilute; it was not responsible for the pollutant waste load. The pollution came from the other process areas drained by the 660 grease drain. The BOD contribution was only 1.2% of the total; Kjeldahl nitrogen is 3.7% of the total.

Center Grease Drain

The center grease drain contributed 8.0% of the total flow and 8.0% of the total Kjeldahl nitrogen. This may be due to blood rinsed off the carcass in the carcass shower.

330 Grease Drain

The 330 grease drain was the fifth largest contributor to the total flow. It is the second largest contributor to total solids because of the large amount of solids washed down this drain during the cleanup shift. Thus, solids elimination was the main problem to focus on for this sample point.

Stomach Washer Drain

The stomach washer drain was a major contributor; it produced 14.4% of the waste water flow and 27% of the grease load. The large grease load was due to the fatty tissue from the outside of the stomach lining which was removed in the tumble washer. This drain is also the third largest producer of BOD and COD and suspended solids. This sample point needs both flow and load reduction.

Hasher-Washer Drain

The hasher-washer drain was the obvious villain of the kill floor. It alone accounts for 63% of the total BOD and COD, 56% of the suspended solids, and 21.5% of the total flow. Cleanup at this point would be a major reduction in the total wastewater load from the kill floor. The neck washer flowed into this drain and contributed a significant proportion of grease and other pollutants to the overall hasher washer total.

IDENTIFICATION OF MAJOR POLLUTANT SOURCES

The preceding discussion points out that the hasher-washer drain, the dehair floor drain, and the stomach washer were the three major sources of pollution from the kill floor. This identification was the main objective of the characterization study. Data in Chapters V, VI, and VII also identifies the shift and the production areas that produced the largest quantities of pollution.

Figure 27 is a flow summary by shifts and by sample point. It can be seen that the production shift is responsible for 244 gal./1000 lb LWK for a total of 362.7 gal./1000 lb LWK.

Figure 28 shows the sources of total BOD load by shift and process area. The production shift contributed 4.0 lb BOD/1000 lb LWK and the cleanup shift contributed only 0.2 lb/1000 lb LWK. The pattern for total Kjeldahl nitrogen and other pollutants follows the same pattern. Correlations of parameters shown in Appendix D support this statement. Also, Tables 11 and 12 bear this out.

Modifications to reduce pollution should be made during the production shift. The most critical areas are the hasher-washer, the stomach washer and the dehairing. These three production shift sources represent nearly ninety percent of the BOD load. This does not mean that cleanup and process modifications in other areas should be scorned but it does show dramatically how initial characterization guides later efforts in the most important directions.

Maximizing money saved per dollar spent on modification will be accomplished by giving most effort to the large pollution sources. After they are removed or reduced a series of smaller conservation steps will remain.

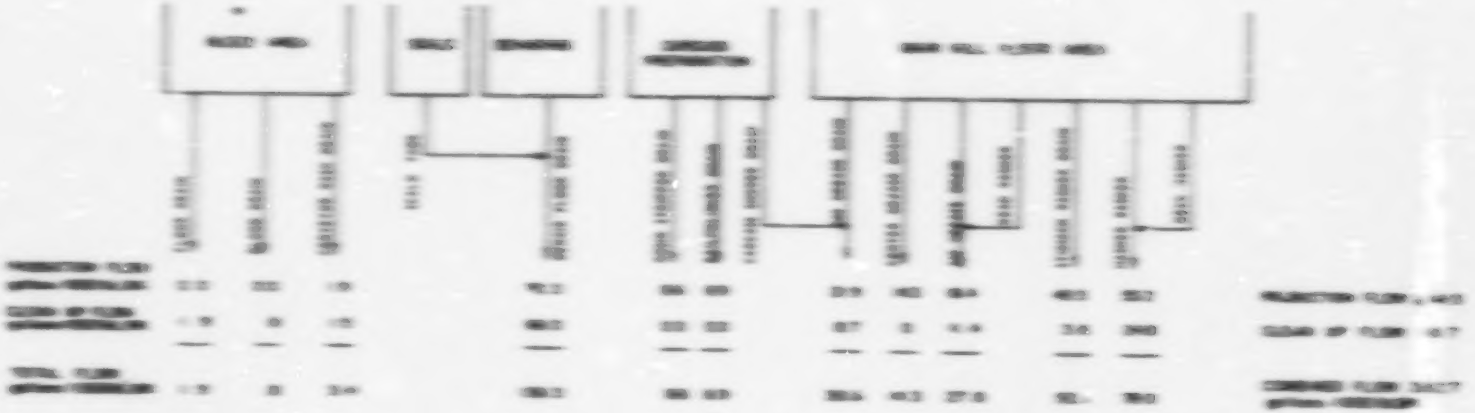


Figure 23. Wastewater flow balance for the [illegible] production and cleanup shifts.

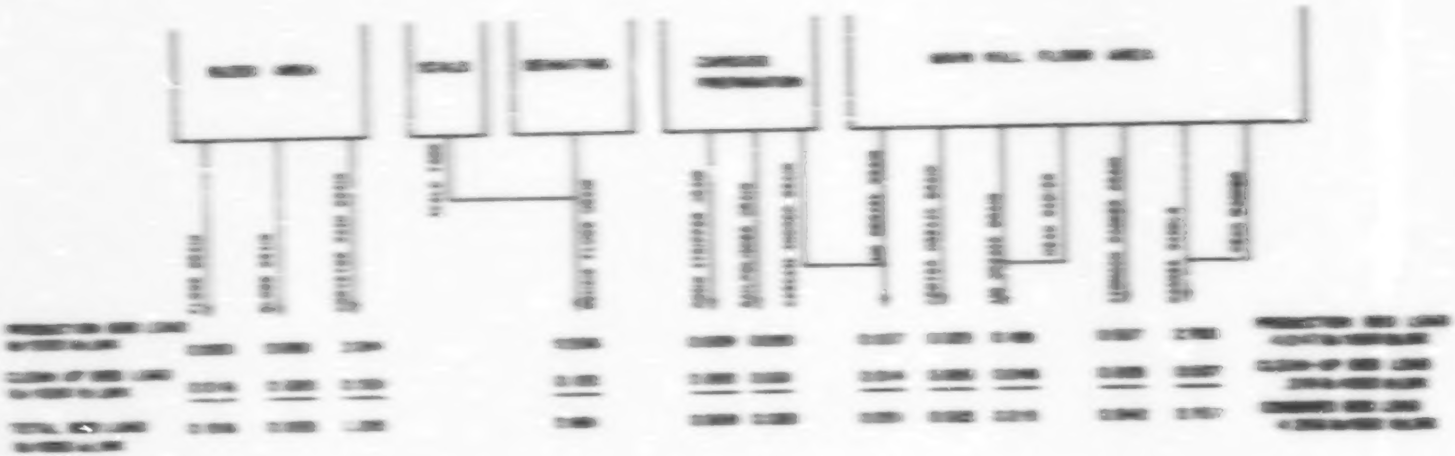


Figure [illegible]. [illegible] mass balance for the [illegible] production and cleanup activities.

SECTION VIII

PROCESS CHANGES AND RECHARACTERIZATION

INTRODUCTION

The initial characterization of wastewaters and visual plant inspection indicated the areas which produced the greatest amounts of pollutants and which used the largest volumes of water. This information guided redesign and process changes. In a few cases one of the plants was using water in a particular process more efficiently than the others and this plant could be used as an example.

Implementation of desirable changes was not always simple or possible. Fearing delays could cost dearly in terms of lost labor and loss of production, management was reluctant to test some ideas. Even when changes were made, many delays were experienced in installation of equipment and process redesign features due to a shortage of trained mechanical personnel available for this project. Because it was not possible to test all changes that were thought to be desirable, in this chapter not only are the actual changes that were tested presented and discussed, but also tests which should have been made and changes which are clearly worthwhile are presented. **Tables 13 and 14 are a summary.**

CHANGES IN THE STICK AND BLEED AREA

Problem: Most of the blood which is washed down the bleed area floor drain during cleanup originates as a production shift problem. The two sources of blood entering this drain are drippings from the chain or bleed conveyor and blood overflowing the bleeding trough. The overflows are intermittant and rather infrequent overflows occur when heavy blood clots collect along the bleeding trough. When these clots become too thick and heavy, they suddenly break free and 100 to 150 lb (45 to 70 kg) of blood pours down the trough and overtaxes the capacity of the receiving piping which should carry the blood from the trough into the blood recovery system.

Table 13. SUMMARY OF CHANGES IN POLLUTION LOAD AND FLOW

Item	Production shift			Cleanup shift			Production & Cleanup		
	Flow gal/shift	BOD lbs/shift	SS lbs/shift	Flow gal/shift	BOD lbs/shift	SS lbs/shift	Flow gal/day	BOD lbs/day	SS lbs/day
Original conditions	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Reduction	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Percent reduction	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Net after change	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table [illegible]. [illegible]

Sampling point	Production shift			Cleanup shift			Production & cleanup		
	Flow gal/batch	BOD lb/batch	SS lb/batch	Flow gal/batch	BOD lb/batch	SS lb/batch	Flow gal/batch	BOD lb/batch	SS lb/batch
[illegible]	0	0	0	0	5	0	0	5	0
[illegible]	0	0	0	0	5	0	0	5	0
[illegible]	[illegible]	0	0	0	0	0	[illegible]	0	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	0	0	0	0	0	0	0	0	0
[illegible]	[illegible]	–	–	–	–	–	[illegible]	0	0
[illegible]	[illegible]	0	[illegible]	0	[illegible]	0	[illegible]	0	0
[illegible]	[illegible][a]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	0	0	0	[illegible]	0	[illegible]	0	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	0	0	0	0	0	0	0	0	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	[illegible]	[illegible]	[illegible]
a. [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
b. [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
c. [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[a] Values in parentheses are a subset of the above value and are not included in the total.

Solution: A change in technique solved this problem. The man who sticks the hogs now positions every 30th or 40th hog so that one front leg drags along the trough as the hog is conveyed into the scald tank. This prevented collection of large clots, eliminated the overflow problem, and reduced by about 80% the amount of blood reaching the bleed area floor drain. The residual 20% of the blood that used to enter the bleed area floor drain originates as drippage from the chain, washing of knives and hands, etc., and is not considered recoverable. The result of this change in technique is that 25 lb (11.3 kg) of blood now enters the blood recovery system instead of entering the wastewater system. This is equivalent to about 5 lb (2.3 kg) of BOD as shown below.

$$25 \text{ lbs blood} \times \frac{1}{8.34}\frac{\text{gal}}{\text{lb}} \times 3.78\ \frac{\text{l}}{\text{gal.}} = 11.3 \text{ liters blood}$$

$$11.3\ \text{l} \times 200\ \text{g}\ \frac{\text{BOD}}{\text{l}} \times \frac{1}{1000}\ \frac{\text{kg}}{\text{g}} = 2.27 \text{ kg BOD}$$

$$2.27 \text{ kg BOD} \times 2.2\ \frac{\text{lbs}}{\text{kg}} = 5 \text{ lbs BOD}$$

Problem: After the last hog was killed for the day, six sprays along and above the bleed trough were started to wash some of the blood from the troughs to the blood recovery system. The first sluice of water went to the blood recovery system; after this short initial sluice, drainage was diverted from the blood recovery system to the bleed conveyor floor drain. The first sluicing removed only about 50 to 60% of the blood in the trough and this blood, obviously, was diluted as it entered the blood recovery system. This is inefficient. Another inefficiency associated with this practice is that the remaining 50% of the blood was washed into the bleed conveyor blood drain during the cleanup shift.

Solution: A squeegee with an offset handle was made to remove blood from the blood trough into the blood recovery system without using the initial sluice of water. This dry cleaning procedure increased the amount of blood recovered from 50% of that on the trough as cleanup began to 80 to 90% of the blood that was on the trough at the start of cleanup. This is an increase of 25 lb (11.3 kg) of blood and represents 5 lb (2.3 kg) of BOD removed from the wastewater system. Not only is more blood recovered by this method, but the cost of recovering the blood is reduced because the water added to cleanup does not have to be handled and heated in the blood recovery process. The only blood from the bleeding trough, then, that does not go to blood recovery is blood which is inaccessible because it is beneath surfaces or in pipes where the squeegee cannot reach.

Problem: During production the bleed conveyor was sprayed with cold water to wash blood off the slotted side of the conveyor. This was to prevent the conveyor becoming coated with dried blood that would be difficult to clean off. The water used in these sprays was 2,666 gallons (10,100 l) per typical production shift.

Solution: Tests showed that eliminating these water sprays did not make cleanup of the chain more difficult. The sprays are now used only one or two hr/day and this is during the cleanup shift. These sprays are not operated during the production shift. This saves 2,666 gal. of water/day, and $266/yr (Tables 15 and 16). There is no reduction in pollution loading by elimination of these sprays since the blood which has been washed off by the sprays now drips off onto the floor under the bleeding conveyor or this blood is washed off during the cleanup shift. This blood is not recoverable.

PROCESS CHANGES FOR SCALD TANK

Problem: The scald tank in Madison holds 8,000 gal. of water. This tank is filled once a day and make-up is not used other than condensed steam which has been injected for heating. The contents of the scald tank are dumped during the cleanup shift. This represents 85 lb of BOD (38.6 kg), 152 lb of suspended solids (69.1 kg) and 13 lb of grease (5.9 kg).

Solution: No changes were made in the scald system. The water consumption cannot be reduced and the amount of pollutants cannot be reduced unless the technology is changed. The only way to eliminate the source of pollution would be to skin hog carcasses rather than scald and dehair them. The technology for hog skinning has been developed, but data is not available to allow a comparison of the water use and pollution load from a skinning operation with the load from the processes replaced in a typical slaughtering plant.

PROCESS CHANGES FOR DEHAIRING

Problem: In Madison, during production 50,000 gal. (190,000 l) of potable water are used solely to transport removed hair and toenails from the dehairing machine to the sewage treatment plant and 60,000 gal. (227,000 l) of water are used during cleanup to dislodge hair from the machine and sluice it away. The reason for increased water use during cleanup is that hair drops out of the machine in large matted bunches and, unless large amounts of water are used for sluicing, these bunches plug the dehair floor drain.

Table 15. SLED CONVEYOR WASH FLOW REDUCTION

Item	Gallon/shift	Gallon/1000 lb LWK
Before change		
Production	2,668	1.855
Cleanup	2,140	1.488
Total	4,808	3.343
After change		
Production	0	0
Cleanup	2,140	1.488
Total	2,140	1.488
Net reduction	2,668	1.855

Table 16. SAVINGS DUE TO ELIMINATION OF THE SLED CONVEYOR WASH DURING PRODUCTION

(Based on 250 work days/yr. and a water cost of $0.39/1000 gal)

Net flow reduction = 667,000 gal/yr.

Total annual savings = $260.13

Present value of savings = $985.00
(5 years @ 10%)

The cost of this large volume of water is approximately $10,725/yr in Madison[a]. An additional cost of $8,681 is due to pollution load. Over 5 years at 10% interest this capitalizes to $73,564 which could be invested in process modification. This cost is based on an estimate of 110,000 gal. of water used primarily to transport hair to the sewage treatment plant where the water must be removed so the hair can be hauled to land disposal, and reduced BOD and suspended solids surcharge.

Solution: One possibility with current technology is to reduce the amount of water used to convey hair away from the machine. Oscar Mayer plants use different methods for conveying away hair; other slaughtering plants visited during the course of this study provided additional comparison. Neither the Beardstown or Davenport plants have this extravagant use of hair sluice water. In Davenport hair and toenails are scraped out of the dehairing machine onto a chute which directs the hair into a dump truck. At Beardstown hair is transported from the dehairing machine to the sewage treatment plant by reclaimed sewage, actually effluent from the grease floatation tank which is recycled to the dehairing machine. Other plants which were visited used conveyors to transport the hair from the dehairing machine to a truck for hauling to landfill disposal. If dry conveyance of hair is not possible, use recycled water in minimal amounts for sluicing. See Tables 17 and 18 for estimated savings from using dry conveyance in Madison.

One way to eliminate this source of pollution is to change the carcass handling and skin hogs rather than remove the hair. This technology exists, but there is no data on which to make a direct comparison. Obviously, skinning will substitute a new kind of pollution for that discharged from the scald tank in the dehairing machine. One speculates that this change would be beneficial and data should be compiled to make this comparison in some future study.

CHANGES FOR THE RAIL POLISHER

Problem: Water use in the rail polisher in all plants is too high, principally because cleanup personnel leave the sprays on during cleanup shift. This water serves no useful purpose.

Solution: One solution is better training and supervision of cleanup personnel. This is not always easy to accomplish, so a mechanical solution was developed and tested. The test was made at the Beardstown plant where an automatic switch was installed which turns off the water when the last hog has gone through the rail polisher. A steel push bar is depressed by the hog trolley to activate a solenoid valve on the water supply to the rail polisher.

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[a] This cost is estimated using the current cost of 15¢/1000 gal. for cold potable water, a sewer charge based on the volume of wastewater entering the Madison Sewage System of 24¢/1000 gal. and 250 working days/yr. All cost for water and sewage disposal reported in this chapter will use this basis for calculation unless a specific notation is made otherwise.

Table 17. DEHAIRING MACHINE REDUCTIONS IN FLOW AND POLLUTION LOAD
(gal/1000 lbLWK or lb/1000 lbLWK)

Item	Before change[a]			After change			Net Reduction
	Prod.	Cleanup	Total	Prod.	Cleanup	Total	
Flow	70.79	65.96	136.75	33.52	24.75	58.27	78.48[b]
Total solids	1.223	0.506	1.729	0.619	0.159	0.778	0.951[b]
Susp. solids	0.649	0.247	0.896	0.328	0.078	0.406	0.490
Grease	0.180	0.022	0.202	0.091	0.007	0.098	0.104
TKN	0.131	0.016	0.147	0.066	0.005	0.071	0.076
BOD	0.536	0.125	0.661	0.270	0.039	0.309	0.352
COD	1.308	0.377	1.685	0.660	0.119	0.779	0.906

[a]The change is to replace sluicing of hair from the dehairing machine with dry conveyance.
[b]Multiply by 1437.5 to get gal./day or lb/day.

TABLE 18. ANNUAL SAVINGS DUE TO POSSIBLE DEHAIRING MACHINE CHANGE[a]
(based on 250 work days/year)

Item	Amount
Flow savings:	
110,000 gal/day × 27,500,000 gal/yr @ $0.39/1000 gal. . .	$10,725/yr
BOD surcharge savings:	
506 lb/day × 126,500 lb/yr @ $0.0319/lb.	$ 4,035/yr
SS surcharge savings:	
704 lb/day × 176,000 lb/yr @ $0.0264/lb	$ 4,646/yr
Total Annual Savings	$19,406/yr
Present value of savings:	
5 years @ 10%.	$73,564
Estimated cost of installing dry conveyance system	$22,000
Estimated net present value of savings	$51,564

[a] The cost of water is $0.15/1000 gal for cold potable water plus $0.24/1000 gal for wastewater surcharge. The BOD and SS surcharge are the 1975 Madison rates.

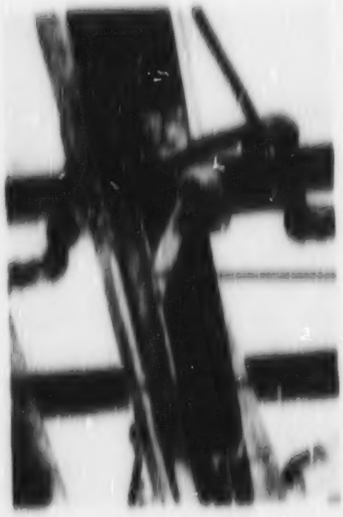

Micro switch
Actuating arm pivot
Switch actuating arm
Kill rail

Figure 29. Beardstown rail polisher automatic shut-off.

if there are not any hogs going through, the water supply is automatically shut off. The shut-off mechanism is shown in Figure 29. There is a bypass piping and valving around the solenoid for use in case of malfunction. To discourage improper use of this bypass, the hand operated valve is inaccessible without a ladder. Different switching, perhaps light rays and photoreceptor tubes, could be used to shut off the water between the passage of individual hogs. The savings from this sophisticated system would be at most 1/3 of the total water use during the production shift, or 12,800 gal./day (48,453 l). The more reasonable target is to eliminate wastage during the cleanup shift which is 1,640 gal. (6,208 l) every hour these sprays are left on, and this unnecessary use of water had been running several hr/day. The cost of the automated shut off was $255.00. The estimated annual savings in water use is 1,600,000 gal. (6,400 gal./day x 250 day/yr) or $624.00.

PROCESS CHANGES FOR CARCASS SHOWER

Problem: The problem is excessive water use. The final carcass shower contributes 60 gpm (3.78 l/s) into the 660 grease drain. This is the primary source of wastewater entering that drain.

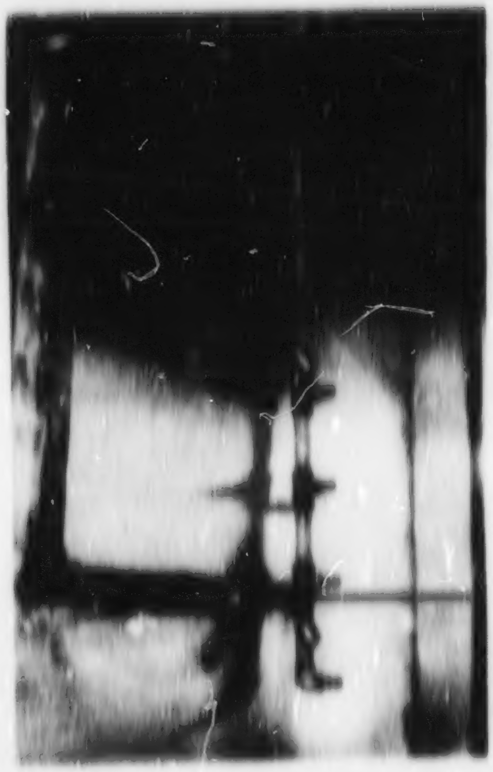
Solution: Different kinds and configurations of nozzles were tried to reduce the volume of water required to clean the hog carcasses. In Madison a series of 6 Veejet nozzles (Spraying Systems Co.) were installed to spray the top of the carcass to sluice off loosened soil (Figure 30). These nozzles did a good job of removing dirt from the carcass and reduced the water use from 60 to 43 gpm (3.78 to 2.7 l/s). Unfortunately, these nozzles created a fine spray mist that carried out of the shower enclosure so that the nozzle arrangement is now being modified. **Tables 19 and 20 list savings.**

In Beardstown, where a rosin depilator is not used, the dirt on the carcass is not so difficult to remove as in Madison. Here it was found that two shower nozzles which spray the feet and hams plus two one-half inch whirl jet nozzles which spray the sides of the carcass are sufficient (Figure 31). Using these nozzles has decreased water use in the carcass shower from 60 to 30 gal./min. The savings would be slightly greater than given in Table 20 for Madison.

CHANGES IN CARCASS WORK-UP AREA

The carcass work-up area is defined as that part of the kill floor after the final carcass shower where the carcass is being trimmed, cut and split. In this section the focus is on water, meat and fat scraps, and blood that falls onto the floor under and around the kill chain. Pollution is eliminated by properly handling these scraps and drippings.

Problem: Eyelids, which are removed from the carcass right after the carcass shower, were dropped onto the floor. Despite periodic dry pick-up many of these meat scraps were washed into the grease drain by water originating in the carcass shower. (In the Madison plant this load was characterized as part of the 660 grease drain).



New sprays
Old style sprays

Figure 30. Madison final carcass shower showing old and new spray configuration in parallel.

Shower nozzles
Plugged "test" nozzles
Spraying Systems Co.
1/2" Whirljet nozzle
detail of nozzle

Figure 31. Beardstown final carcass shower

TABLE 19. CARCASS SHOWER REDUCTIONS IN FLOW

Item	Before change	After change	Net reduction
Production	28,851	20,098	8,753
Cleanup	0	0	0
Total	28,851	20,098	8,753 gal/day[a]

[a] 6.086 gal/1000 lb LWK.

TABLE 20. ANNUAL SAVINGS DUE TO CARCASS SHOWER REDUCTIONS

Item	Amount
Flow savings:	
8,753 gal/day = 2,188,250 gal/yr @ $0.39/1000 gal.	$853/yr
Present value of savings. 5 years @ 10%	$3,233
Cost of installing change	$184
Estimated net present value of savings.	$3,048

Solution: A combination bridge and screen (Figure 32) was built to fit across the drain and gutter to keep eyelids out of the drain. About 12 lb of this scrap formerly entered the drain. The amount of grease, BOD etc. is not known, but there is no doubt that this simple change has reduced the pollution load.

Problem: Trimmings, blood clots, and meat and bone dust from carcass splitting littered the carcass work-up area. Mid-shift and final cleanup personnel often found it more convenient to flush this material into a drain rather than use dry cleanup methods. This caused a large periodic pollution load and loses material for inedible rendering. Dry cleanup with a broom and shovel, the normal procedure, is an effective procedure. A "Tornado" industrial vacuum cleaner shown in Figure 33 was tried for dry cleanup. This cleaner readily picked up blood, floor scraps, sawdust, and even whole kidneys, and left the floor dry, but it was cumbersome and slow. Some congested areas were not accessible. A man with a broom and shovel could do almost as well in less time and with less interference to kill line operations. The vacuum system could be used to good advantage in some places, particularly if installed as a central system, thereby, eliminating the cart, electrical cords, and movable tank.

Problem: When the hog brisket is split open and when viscera is removed large clots of blood fall into the gutter beneath the kill rail. During mid-shift cleanup and final cleanup these are often pushed down the chute leading to the hasher-washer rather than being picked up for rendering. Sluicing to the hasher-washer breaks up the clots and leaches substantial amounts of soluble material.

Solution: The solution is dry cleanup. Training and supervision of personnel is vital. Vacuum cleaning would be effective in some places.

Problem: Blood clots near the viscera removal treadmill fall onto the floor and are washed with water from lavatories, drinking fountains, and the viscera removal treadmill sprays. This leaches soluble material and generates a pollution load.

Solution: More frequent dry pick up of clots would reduce the problem, but not eliminate it. This is not a practical solution because of labor costs. Elimination of the water sources was not a practical solution either. Segregation of the water and the blood clots was practical. A curb was built around the eviscerating treadmill to divert water and prevent it from contacting the clots. Mid-shift dry pick up of these "protected clots" is part of the pollution reduction solution at this location.

The kill method of electrical stunning and hung bleeding used at Beardstown produces more complete carcass bleed-out than the CO_2 immobilization prone bleeding method used in Madison. This reduces blood clots on the floor.

Problem: Bits of fatty tissue, abdominal aorta and skin from around the stick wound are trimmed off and dropped into the gutter. Periodically these were swept into the hasher-washer chute where the sluice water would leach

Figure 32. Bridge and screen used after Madison final carcass shower to keep meat scraps out of the 660 hog/hour kill line grease drain.

Figure 33. Tornado brand industrial vacuum cleaner with two inch wand and floor gulper head.

soluble material. Because of labor standards and work efficiency it was not practical to have the trimmer deposit the scraps into a barrel or other container. The vacuum cleaner was too cumbersome to be efficient in this work area.

Solution: Blood clots and trimmed tissue could be kept off the floor and out of the drains by installing a stainless steel trough under the kill line. Material could easily be collected dry for rendering; no water could contact it and solubilize organics. The kill rail is so low in the Madison plant that such a trough could not be installed without having the heads or ears of sows come into contact with it. This would not be allowable. Such a trough would be useful in many plants where only butcher hogs are slaughtered or where the kill rail is higher.

CHANGES IN VISCERA HANDLING

In this section we deal with changes on the evisceration treadmill and the viscera pans. Some process changes in the area of the evisceration treadmill were discussed previously. Those changes were in connection with material which had fallen onto the floor around the viscera handling area.

Problem: There is a continual loading of blood and other material which is washed off the eviscerating treadmill by water spray. These sprays used a total of 15 gal./min, part of which is 180°F water which is used to sanitize the treadmill and part of which is cold water spray to loosen blood and other matter. The problem was to reduce the amount of water used for washing.

Solution: Experiments showed that cleaning with only 5 gal./min of water was sufficient. The reduction in water use was accomplished by installing new nozzles in the spray system. The nozzles from the Spraying Systems Company are as follows: 1/8 K 1.0 nozzles on 6 in. center located 3 in. from the treadmill for the cold water washer; 1/8 K 2.5 nozzles on 6 in. centers located 3 in. from the treadmill for the hot water water sanitizing sprays (Figure 34). The change saved 4,670 gal. (17,678 l) of water/day on the treadmill alone which is $ 455.00 annually*. The cost of making the change was $63.00.

Problem: The greatest contributor of water to the hasher-washer drain in the Madison plant is the viscera pan washer on both the 650 and 330 kill line. The problem was to reduce the water required to wash and sanitize the viscera pan. The washing procedure consisted of a cold water wash followed by a hot water (180°F) sanitizing water spray, followed by a cold water rinse to cool viscera pans. The cold water wash consisted of two 1 1/2 in. water pipes which were perforated with 1/8 in. holes drilled 1 1/2 inches apart. One of these spray pipes was located above the viscera pans and one was located below the pans.

Solution: The old spray system was replaced with new nozzles. The nozzles were placed on 8 in. centers at a 6 in. distance from the viscera pan conveyor to spray the backs of the pans and 6 nozzles spaced on 6 in. centers at a distance

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*10 gpm (7.79 hr/day) (60 min/hr) (250 day/yr) ($0.39/1000 gpm) = $455.

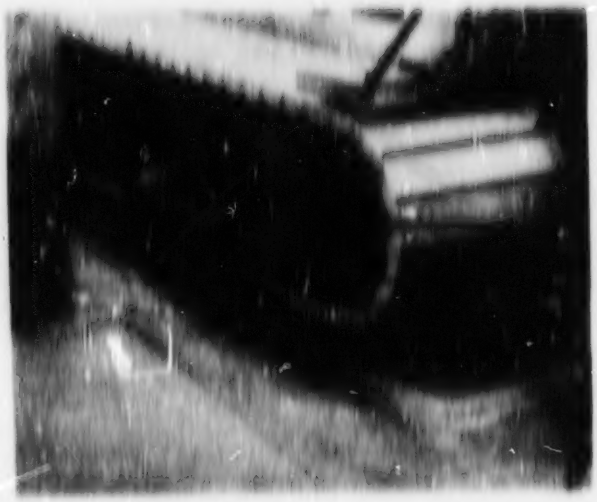
spray for
washing treadmill
segregating curb

Figure 14. Madison eviscerating treadmill.

of 6 in from the pan to wash the insides of the pan. This nozzle change reduced the water used to clean and sanitize the viscera pans from 115 to 40 gal./min. Tables 21 and 22 give an accounting of the pollution and monetary savings for all the changes in the evisceration area; that is, the curb around the treadmill which segregates water and blood clots so blood clots can be cleaned up dry, changes in the treadmill washing, and changes in the viscera pan washing. These changes are shown in Figure 34. Tables 21 and 22 document the changes and savings.

Problem: Excessive amounts of water were being used on the viscera pans and the evisceration treadmill during cleanup. The cleanup men would leave the viscera pan and treadmill sprays on during most of the cleanup. After the first thirty minutes, this accomplished no useful purposes.

Solution: Solenoid valves were installed on [illegible] water lines which supply the viscera pan sprays and treadmill sprays. These [illegible] are controlled by a locked timer box. During production the timer is [illegible] manual operation and the solenoid valves remain open. At the end of production the timer is set on automatic and the control cabinet is locked. To use the sprays the cleanup man must push a button on the control cabinet to activate the timer and open the water supply valve. The timer automatically closes the solenoid valve after 15 min. The sprays can be restarted by pushing the button again if more water is needed, but they cannot be left running by inaction or carelessness. This automated lockout would not be required if cleanup workers were properly motivated toward good conservation practices and were well supervised. In many plants the automation will be the practice which is certain and effective. Table 23 documents the savings accomplished by using this automated valve during cleanup shift.

CHANGES IN THE HASHER-WASHER

Several of the changes mentioned previously to collect scraps from the floor and prevent leaching of soluble materials were designed to keep scraps out of the hasher-washer drain. In this section we consider a major improvment made in the hasher-washer itself.

Problem: The hasher-washer drain is the largest contributor of pollution load from the kill floor. Intestines and great quantities of other solid materials are sluiced into the hasher-washer from various parts of the kill floor. Knives in the hasher-washer slash the intestines and this enables the sluice water to flush out the intestinal contents. The objective is to have fat and meat solids go to inedible rendering and to have wastewater go to the wastewater treatment plant. The separation of solids and the liquid is very inefficient. Large quantities of solids escape with the water through the large slots in the hasher-washer drum. The problem is to send less of the solid material, which represents an extremely high load in terms of BOD solids, grease, and other pollutants, to the wastewater treatment plant and to capture these materials for rendering.

Solution: One solution would be to design a hasher-washer with smaller slots that could recover a greater portion of the solid material. A similar

Table 31. REDUCTIONS IN FLOW AND POLLUTION LOAD DUE TO EVISCERATION TREADMILL AND VISCERA SPRAY CHANGES: SEGREGATION, VACUUM CLEANUP, AND NEW NOZZLES (gal/1000 lb LWK or lb/1000 lb LWK)

Item	Before change	After change	Net reduction
Flow	53.14	25.70	27.1[a]
TS	1.433	0.883	0.550[a]
SS	0.324	0.320	0.004
Grease	0.255	0.213	0.042
TKN	0.134	0.052	0.072
BOD_5	0.650	0.529	0.121
COD	1.581	0.953	0.628

[a] Multiply by 1437.5 to get gal/day or lb/day

TABLE 22. ANNUAL SAVINGS DUE TO EVISCERATION TREADMILL AND VISCERA SPRAY REDUCTIONS OF TABLE 21 (Based on 250 work days/yr and costs of \$0.39/1000 gal, \$0.0319/lb BOD_5, and \$0.0264/lb SS)

Item	Amount
Flow savings:	
39,427 gal/day × 9,856,750 gal/yr	\$3,844/yr
BOD savings:	
170 lb/day = 4,250 lb/yr	\$ 136/yr
Loss due to increased SS	Negligible
Net annual savings	\$3,980
Present value of savings:	
5 years @ 10%	\$15,087
Installation cost	\$ 2,377
Net present value of savings	\$12,710

TABLE 23. ANNUAL SAVINGS DUE TO USE OF LOCKOUT SWITCH FOR CLEANUP OF EVISCERATION TREADMILL[a]

Item	Amount
Annual savings:	
7,456,250 @ $0.39/1000 gal	$ 2,907
Present value of savings:	
5 years @ 10%	$11,019
Installation cost	$ 1,285
Net present value of savings.	$ 9,734

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[a] No change in BOD or SS; flow reduction = 29,825 gal/shift
= 7,456,250 gal/yr.

solution would be to follow the existing hasher-washer with a second screening operation that would capture smaller particles. Neither of these alternatives was tested because a better solution existed. The chopping blades were removed from the hasher-washer (Figure 35) so the unit functioned only as a dewatering device. The large and small intestines and their contents remain intact and are sent to inedible rendering. This increases the quantity of meat scrap and material for rendering by an average of 8,500 lb/day. The present value for rendered meat scrap is $5.75/100 lb; this 8,500 lbs/day is worth $488.75. This additional income is not the total savings associated with the change because allowance must be made for savings in wastewater treatment. Analysis of the meat scraps produced during the test period did not indicate reduction in the quality, although the crude fiber content of the meat scraps did increase from 1.5% to 1.7%.

The solids from the hasher-washer are rendered to produce grease and meat scraps. During the test with the hasher-washer blades removed, there were several customer complaints about the quality of the choice white grease. Some of this grease had to be downgraded to A-white with the resultant loss in the selling price of .50/100 weight. (Choice white grease is $14.75/100 weight, and A-white grease which is lower quality is $14.00/100 weight). During the years 1971 through 1975 the Madison plant produced an average of 5,188,000 lb of choice white grease/yr. If this total production were downgraded to A-white, there would be a loss in income of $25,940/yr. This is offset by the increase in meat scraps going to rendering which was estimated as $488.75/day which over 250 working days/yr approximates $122,000. This accounting is not exact. The extra cost of drying the additional meat scraps, the savings in power and maintenance in not running the hasher, and savings in wastewater treatment have not been included.

Removing the hasher-washer blades gave a substantial reduction in BOD suspended solids, and other pollutants going to the wastewater treatment facility. See Tables 24 and 25 for detailed pollution and cost data.

CHANGES IN THE STOMACH WASHER

Problem: Water is used to flush out the contents of the stomach. The stomach contents represent a high pollution load. Even if the solids are captured later and separated from the water, there has been significant pollution load generated as soluble materials. This was shown by mixing a portion of stomach contents with an equal volume of water and filtering this mixture through a 20 mesh screen. The filtrate had a total solids content of 41,000 ppm, total volatile solids 37,000 ppm, and BOD$_5$ of 42,000 ppm. The objective was to eliminate the leaching of pollutants from stomach contents during washing and sluicing.

Solutions attempted: Attempts to reduce water use and pollution generation in the stomach washer were unsuccessful. The results of our attempts are reported, nevertheless, in hopes of stimulating a workable solution in the future. Reducing the flow of water in either the stomach slitter-dumper or the stomach tumble-washer led to the failure of these units to clean the stomachs adequately.

Figure 35

Madison Hasher-Washer With Hasher Blades Removed.

Table 24. REDUCTION IN PRODUCTION SHIFT POLLUTION LOAD DUE TO REMOVAL OF HASHER WASHER BLADES

Item	Before change	After change	Net reduction	
			lb/1000lbLWK	lb/day
Flow	No	change	--	--
BOD lb/1000 lbLWK	2.70	.6498	2.050	2948
SS lb/1000 lbLWK	2.35	.324	2.020	2906
TS lb/1000 lbLWK	4.34	1.433	2.907	4180
Grease lb/1000 lbLWK	2.88	.255	2.625	3775
TKN lb/1000 lbLWK	.23	.134	0.096	138
COD lb/1000 lbLWK	6.80	1.581	5.219	7505

TABLE 25. ANNUAL SAVINGS DUE TO REMOVING THE HASHER BLADES (Based on 250 work days/yr and costs of $0.39/1000 gal, $0.0319/lb BOD, and $0.0264/lb SS)

Item	Amount
Flow savings	None
BOD savings:	
2949 lb/shift = 737,250 lb/yr	$23,518/yr
SS savings:	
2906 lb/shift = 726,500 lb/yr	$19,179/yr
Total annual savings	$42,697
Annual added value due to increased meat scrap:	
8500 lb/day = 2,125,000 lb/yr @ $5.75 per CWT	$122,187/yr
Annual loss due to downgrading grease quality	$35,940
Annual net savings	$128,944
Present value of savings	
5 years @ 10%	$526,681
Cost of modification	$ 275
Net present value of savings	$526,406

Tests were made to see if the stomachs could be slit, dumped, and flushed as they are now with a screening to recover the solids immediately following these other operations. The contents might be dried and fed to the hogs in the stockyard. Analysis of the composite sample of the stomach contents of 85 hogs showed 81% moisture and 1.49% protein. The filtration test (the filtrate characteristics of which were reported above in the problem definition section) showed that the solids could be recovered on a screen and that the filtered solids were 1.03% protein. So much material has been solubilized that the reduction in the BOD_5 load is probably not worth while. The screening might as well be done at the sewage treatment plant as is the present practice. Dry removal and handling of the stomach contents would give a substantial pollution reduction if a method can be found to accomplish this economically.

CHANGES IN HEAD AND NECK WASHING

Problem: The scouring action of the neck washer removes fatty tissues from the neck and jowl area of the carcass and removes blood from the stick wounds. Excessive amounts of water are used and there is a large pollution load generated.

Solutions: An attempt was made to eliminate water use and the pollution by using a vacuum device to remove blood clots from the neck. The vacuum, however, was unable to remove the clots which were firmly embedded in the connective tissues. It was necessary to use water to dissolve the blood clot in combination with mechanical action to get the neck clean. A Chad neckwasher, was installed in the Madison plant to replace the two or three men who previously washed the necks with manually operated scrubbers. The Chad neck washer uses 20 gal./min of water at 800 psi pressure to scour blood and soil from the neck. The method previously used consumed 26 gal./min. Figures 36 and 37 show the Chad neck washer. Tables 26 and 27 give an accounting of the pollution and dollar saving due to installing the new Chad neck washer.

The sprays of the Chad washer spray most of the interior of the carcass and the lower part of the neck as well as the neck itself. Because of this it is believed that the Chad neck washer could be used to wash the head and the interior of the carcass and the stick wound area of the neck. If this proves true, the need for a head washer will be eliminated. This elimination of the head washer would save 6,520 gal./day. This idea cannot be tested without moving the neck washer from its present location to a place right after the kidney removal station. This may be done in the future, but not until the efficiency of the Chad washer has been fully proven.

Problem: The head washing equipment contributes a major portion of the flow and pollution load into the Madison plant's 330 grease drain. The USDA has no specific requirements for a head washer. Its function is to remove blood and stomach contents which have dripped onto the heads to make the heads easier to handle in the trimming operation.

Table 26. REDUCTIONS IN PRODUCTION SHIFT LOAD DUE TO INSTALLING THE [illegible] [illegible] WASHER

Item	Before change	After change	Net Reduction	
			gal/1000 lbs LWK	lb/1000 lb LWK
Flow	12,302	9,348	2,954[a]	—
TS	1.020	0.321	—	0.699[a]
SS	0.472	0.207	—	0.265
Grease	1.520	0.134	—	1.386
BOD	0.360	0.181	—	0.179

[a] Multiply by 2437.5 to get gal/day or lb/day.

TABLE 27. ANNUAL SAVINGS DUE TO INSTALLING THE CHAD NECK WASHER (Based on 250 work days/yr and costs of $0.39/1000 gal, $0.319/lb BOD, and $0.0264/lb SS)

Item	Amount
Flow savings:	
3034 gal/day = 758,500 gal/yr	$ 295
BOD savings:	
257 lb/day = 64,250 lb/yr	$ 2,049
SS savings:	
381 lb/day = 95,250 lb/yr	$ 2,514
Total annual savings	$ 4,858
Present value of savings	
5 years @ 10%	$132,132
Costs:	
Equipment purchase	$ 17,200
Equipment installation	$ 450
	$ 17,650
Net present value of savings	$114,482

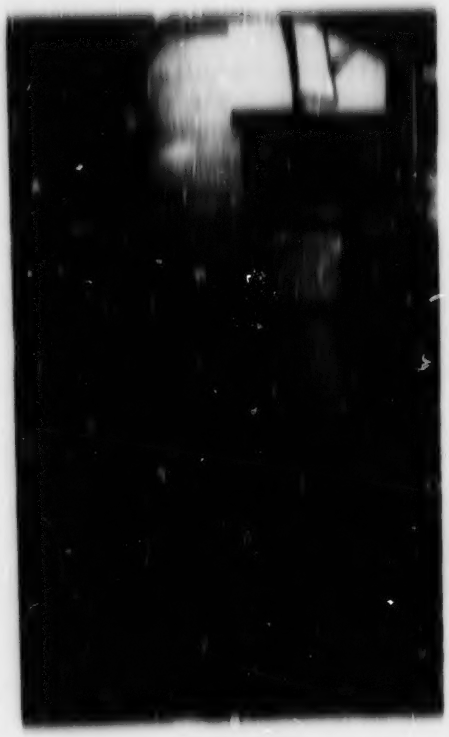

Figure 36. Chad automatic neck washer.

Figure 37. Interior of Chad neck washer showing position of spray manifolds.

Solution: The flow was reduced from 6,520 gal./shift to 3,260 in the head washer by removing three of the six spray nozzles and by decreasing the flow to the three nozzles which remained. The cost savings in water are approximately the same as those reported in Tables 26 and 27 for the neck washer. It is believed that even these three nozzles could be eliminated by relocating the Chad neck washer. In the Beardstown plant, a head washer step is not used. This is because the carcasses bleed out more completely because they are shackled and hung vertically after sticking and, therefore, very little blood drips onto the head.

CHANGES IN CHITTERLING WASHING

Beardstown is the only Oscar Mayer Plant still saving chitterlings.

Problem: Excessive amounts of water were used to flush manure from the chitterlings. Additional large amounts of water were being used to wash workers hands. Most of the water was being discharged through eight shower type spray nozzles located along the chitterling machine.

Solution: The shower type nozzles were replaced with Spraying Systems Company 3/8 in GG "Full jet" nozzles. Meter readings indicate that the average water use for the three chitterling washers has dropped from 112,500 gal./day to 60,685 gal./day. The amount of each pollutant before the change is not known exactly. It is believed that the pollutant load would not change. The savings based on the flow alone at $0.39/1000 gal., is $5,061/yr.

SUMMARY

The list of solutions reviewed in this chapter represent a net present value over five years (at 10% interest) of more than one-half million dollars. It is remarkable how small process changes, made with little or no expense, add up to savings of thousands of dollars annually. Reductions in water used alone is a great savings, and there is the added benefit that decreasing the water use always brought a reduction in BOD, suspended solids, and other pollutants. Often there was increased by-product recovery, as well.

In-plant changes ranging in complexity from shutting off a valve to altering a piece of machinery radically are an economic boom. They can be done quickly. They pay for themselves in a very short time, within a few weeks to a year. They are the best route toward meeting effluent discharge standards.

This chapter has documented how worthwhile in-plant modifications can be. The plant manager who makes searching for potential changes a habit will be well rewarded.

SECTION IX

A STRATEGY FOR IN-PLANT REDUCTION STUDIES

INTRODUCTION

This study shows that even small process modification represent savings of thousands of dollars over a few years. For example, a reduction of 10,000 gal. water/day is roughly $1,000/yr saved. Additional savings due to BOD and suspended solids reductions is probably available, as well. This section outlines a strategy for making a plant survey to identify valuable process modifications; first the gross problems and then the smaller problems. The goal is to provide advice that can help an industry that must accomplish this by itself without investing great amounts of time and money in data collection. A research program such as described in this report is not required to bring savings to small industries.

A SEQUENTIAL STUDY STRATEGY

The strategy, in rough outline, has three stages.

1. Make a walk-through survey during production and cleanup to identify points of water use, gross spillage, and collections of blood and scrap on the floor. This visual survey will identify gross problems and these are the targets of first attack. Generate a list of possible solutions for each problem site (such as broom and shovel pick up, install a catch trough, curb an area to divert water, install an automatic shut off, etc.). If the cost of a change is less than $500, it will repay its cost many times over within 5 years. If the cost is higher, even several thousand dollars, it may well be profitable. Make an estimate of the water use and pollution load using data from this report and other meat packing literature to assess economic viability. Often the change is profitable for the water savings alone; estimates of BOD and other measures of pollution may not be needed to make the decision. Remember, the purpose of the in-plant survey is to make decisions and not to quantify everything with great precision and accuracy. Install the changes that seem attractive on the basis of this first analysis.

2. The first step has been taken and data is needed to make decisions on additional process modifications. The strategy now is to get decision making information quickly and without a massive measurement program. Because savings in water alone are so significant, flow measurements should be made. The two techniques of greatest value are the bucket-and-stop-watch method, and the lithium chloride dilution method. (We assume extensive water metering does not exist). Use the bucket for small accessible flows. Use the

lithium dilution method for large flows and flows that are not accessible to the bucket method. Addition of the lithium to the wastewater flow that is to be quantified is simple. The only problem for most plants is getting the diluted lithium concentration measured, because this is done best by atomic absorption. The samples can be sent to a commercial laboratory or a government or university laboratory for a reasonable price. Most meat packers have the capability for measuring total Kjeldahl nitrogen. They may also have the set-up to measure BOD, COD or suspended solids. Measure BOD if it is convenient; if not, measure COD and measure suspended solids. If these measurements are not possible, the Kjeldahl nitrogen measurement is a useful surrogate for BOD and COD. Analyse at least two or three samples. The relations given in this report can be used only as very crude prediction equations in another plant. They may establish the magnitude of a pollution problem well enough to show that a change is profitable. Again, the focus is on decision making rather than precise quantification. It is granted that some decisions are close ones that require careful quantification and a complete economic evaluation. But more, it seems from the outcome of this research, are easily evaluated with a small amount of information.

3. Steps 1 and 2 have taken care of the easy decisions. To go farther requires more complete data. This can be expensive, but the investment should repay itself. Discovering one problem of sufficient magnitude may pay for the entire sampling program and the cost of installing the change, as well. And there are savings from steps 1 and 2 that can be allocated fairly to paying for step 3, particularly because the analysis expense in the first two steps has been reduced so drastically. In this step it is not necessary to survey the entire plant at one time. A process by process or area by area study can be done, and this would be guided by knowledge gained in steps 1 and 2.

Water meters should be installed at critical locations. The plant should make arrangements to have BOD(or COD or organic carbon), suspended solids, and Kjeldahl nitrogen measurements done "in house" or on contract. Sampling ports and automated equipment should be catalogued and compared against the survey requirements. Work to provide sampling access will be normally necessary because the drain systems in most plants are complex. Carefully work up the budget for the survey. The cost may run from a few hundred dollars to do properly one process area to thousands to do the entire plant. Do not be intimidated by a high cost, but do cull the program to conform to a previously developed priority list.

An important pre-measurement step, too often overlooked, is generation of the optimistic and pessimistic economic outcome of the study results. To make these estimates you must know the cost of water and other plant utilities, sewage treatment surcharges, the probable impact of industrial cost sharing legislation in your community, likely and possible changes in your required level of wastewater treatment, and the selling price of renderings, grease, or other marketable materials that may be affected by changes in the process. This same information is used later when the data is in hand to refine the estimates.

The in-plant survey undertaken will be similar in many respects to that described in this report, although it may not cover the entire plant and the data bank may not be so massive. The five steps that will be undertaken are:

-characterization of wastewater streams and processes,
-design of process modifications and economic evaluation,
-installation of attractive process changes,
-recharacterization to certify effectiveness of the change,
-updating the economic impact of the in-plant survey and wastewater
 reduction program on plant finances.

THE COST-BENEFIT FACTOR

Sometimes the pollution control problem requires that rather massive modification be considered. Management then insists upon a more orderly and detailed evaluation. The cost of the modification is estimated easily, but the total benefits are elusive. A special problem exists when several alternate modifications, each being expensive and producing benefits, are to be studied. Each alternative can be evaluated by a systematic approach as outlined in Figure 58.

The industry may first realize it has a serious economic problem related to pollution control through violation of an effluent standard, payment of excessive surcharges to a municipality, or a shocking result from an industrial cost recovery study. In each case the major question may become "Shall we improve our treatment plant, make in-plant conservation efforts, or pay someone else to take our problem?" The division of investment between treatment and in-plant changes is difficult only when the in-plant change represents a drastic process modification. Even then it may be the wisest course. Certainly, for simple modifications as documented in this report, the in-plant change is a proven winner. A few thousand dollars invested in treatment facilities does little and probably returns no profit. The same investment inside to reduce the generation of wastewater can do a great deal. There are, nevertheless, occasions when major projects need to be studied in detail. A few of the important considerations are given here.

The cost of organizing a study and implementing a proposed change must be weighed against the benefits of lower water bills, reduced sewer charges, reduced treatment costs, and increased by-product recovery. The cost/benefit analysis must be considered for several years into the future. The uncertainty of future labor, energy, raw water, and wastewater treatment costs makes the analysis very difficult and requires careful judgment by the industry.

The first step for the industry is to realize that a pollution problem exists or that a savings can be made by reducing its total effluent load. This realization may be the result of violation of an effluent constraint, excessive user charges, or industrial cost sharing studies.

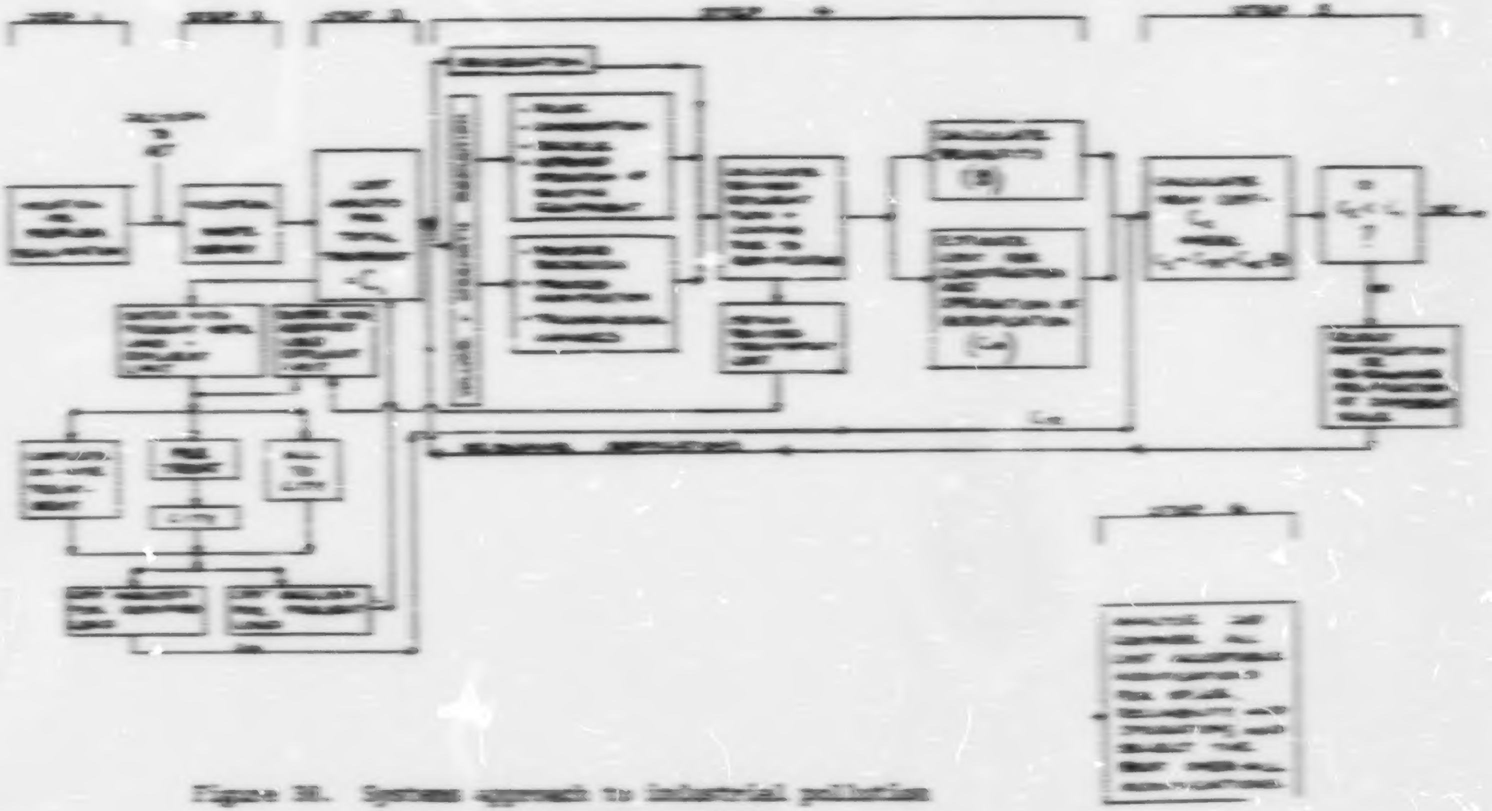

Figure 38. Systems approach to industrial pollution control cost-benefit analysis.

Once the industry decides to act, step two is a survey of "in house" operations to pinpoint major problem areas and sources for potential improvement. The most difficult decision facing the industry is selecting the most cost-effective changes.

The third step requires the industry to make a detailed analysis of the present or expected treatment and disposal costs (C_1). This is the basis of comparison for the revised costs. One industry may operate a primary and secondary treatment facility and discharge the treated effluent into a municipal sewage district interceptor. Other industries may have complete on-site treatment. In all cases the present cost of disposal, the method used for calculating that cost, and an estimate of future changes in those costs should be understood. It is often difficult to estimate accurately the "real" present treatment cost. This is due to the poor segregation of all costs associated with wastewater treatment from general corporate costs. Estimates of treatment costs often do not include administrative costs for secretaries, engineers, processing plant managers, vice presidents, and other personnel who spend a portion of their time with different aspects of the pollution problem. The vice president of finance may spend a great deal of time arranging financing for a treatment facility, and a public relations manager may devote time and resources to keeping the public informed concerning the company's pollution efforts. These costs and others are definitely associated with pollution control and should be included when making a valid cost/benefit analysis. If the pollution problems were eliminated, then personnel could direct their efforts toward maximizing corporate profits.

The fourth step in this approach involves studying each proposed modification and estimating the pollution reduction and water conservation that can be achieved. The reduced effluent load is used for calculating the revised treatment cost, and the cost for installing and operating the modification. Also, any benefits due to reduced raw water volumen and by-product recovery can be calculated.

If the net result is a savings, install the modification. If the new cost is greater than the original cost, reject or re-examine the modification. If an initial segregation modification is rejected, a more complete segregation can be examined.

The viable modifications are compared and the ones with the best cost/benefit analysis are chosen if they also satisfy the company's requirements for space, ease of operation, reliability, and other factors. The best judgment of the industry must be used to select the modifications which will achieve a least-cost, long-run solution to its pollution problem.

It is important to note that the treatment costs and by-product recovery values are on an annual basis, while the cost for the modification is a one-time cost. Present value analysis should be applied to account for the time value of money. At times when industries are faced with tighter capital markets, in-plant reduction can be a method for reducing treatment costs with minor capital expenditures.

SUMMARY

In-plant wastewater reduction studies offer significant savings to industries. Studies should progress from a "first cut" to a complete industrial survey unless the desired reductions are achieved. Industries must decide if they should invest additional money in a wastewater treatment plant or invest that money in more efficient process equipment.

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APPENDICES

APPENDIX A. PRODUCTION SHIFT DATA

TABLE A-1

INITIAL CHARACTERIZATION OF THE HOG SLAUGHTERING FLOOR
(PRODUCTION SHIFT) FOR THE MADISON PLANT

FLOW SUMMARY

Sample point	Gallons/ shift	Liters/ shift	Gallons/ 1000 lb LWK	Liters/ 1000 kg LWK	Percent of load
Blood area floor drain	-	-	-	-	-
B-end conveyor blood drain	-	-	-	-	-
Blood conveyor wash drain	2868	10855	1.9	15.48	0.8
Dehair floor drain + scald tank	101096	382640	70.3	586.6	28.8
Rosin stripper	12490	47275	8.6	72.5	3.6
Nail polisher drain	12797	48438	8.9	74.3	3.6
"960" grease drain	31472	119122	21.9	182.4	9.0
Carcass shower	(28052)	(106177)	(20.1)	(167.4)	(8.2)
Center grease drain	20565	77840	14.3	119.3	5.9
"330" grease drain	23533	89074	16.4	136.6	6.7
Head washer	(6525)	(24698)	(4.5)	(37.8)	(1.8)
Stomach washer drain	69696	263791	48.5	404.6	19.9
Bunker washer drain	75436	285523	53.2	443.5	21.8
Neck washer	(12383)	(46867)	(8.6)	(71.8)	(3.5)
Total	350711	1327452	244	2035	100%

TABLE A-2

INITIAL CHARACTERIZATION OF THE HOG SLAUGHTERING FLOOR (PRODUCTION SHIFT) FOR THE MADISON PLANT

TOTAL SOLIDS SUMMARY

Sample point	mg/l	Pounds/ shift	Kilograms/ shift	Pounds 1000 lb LWK	Percent of load
Bleed area floor drain	-	-	-	-	-
Bleed conveyor blood drain	-	-	-	-	-
Bleed conveyor wash drain	2340	50	23.6	0.036	0.5
Dehair floor drain + scald tank	2090	1760	799.0	1.225	16.6
Rosin stripper	750	77	35.1	0.054	0.7
Nail polisher drain	930	99	45.0	0.069	0.9
"660" grease drain	750	195	88.4	0.136	1.8
Carcass shower	(550)	(133)	(60.1)	(0.092)	(1.3)
Central grease drain	750	127	57.6	0.088	1.2
"330" grease drain	3150	618	280.6	0.430	5.8
Head washer	-	-	-	-	-
Stomach washer	2430	1411	640.9	0.961	13.3
Hasher washer drain	9790	6242	2831.6	4.34	59.0
Neck washer	(14230)	(1470)	(666.5)	(1.02)	(13.9)
Total	——	10579	4801.8	7.36	100%

TABLE 1-3

INITIAL CHARACTERIZATION OF THE HOG SLAUGHTERING FLOOR (PRODUCTION SHIFT) FOR THE MADISON PLANT

VOLATILE SUSPENDED SOLIDS SUMMARY

Sample point	mg/l	Pounds/ shift	Kilograms/ shift	Pounds 1000 lb LWK	Percent of load
Bleed area floor drain	-	-	-	-	-
Bleed conveyor bloof drain	-	-	-	-	-
Bleed conveyor wash drain	210	4.7	2.1	0.003	0.1
Dehair floor drain + scald tank	990	835	379.0	0.580	18.1
Rosin stripper	60	5.9	2.7	0.004	0.1
Rail polisher drain	120	12.2	5.5	0.008	0.3
"660" grease drain	100	26.1	11.8	0.018	0.6
Carcass shower	(20)	(5.2)	(2.4)	(0.004)	(0.1)
Center grease drain	245	42.1	19.1	0.029	0.9
"330" grease drain	500	114.6	52	0.080	2.5
Head washer	-	-	-	-	-
Stomach washer	1500	871	395.0	0.606	18.9
Basher washer drain	4230	2696	1223.0	1.880	58.5
Neck washer	(6190)	(639)	(289)	(0.440)	(13.8)
Total	——	4607.6	2090.2	3.200	100%

TABLE A-4

INITIAL CHARACTERIZATION OF THE HOG SLAUGHTERING FLOOR (PRODUCTION SHIFT) FOR THE MADISON PLANT

SUSPENDED SOLIDS SUMMARY

Sample point	mg/l	Pounds/ shift	Kilograms/ shift	Pounds/ 1000 lb LWK	Percent of load
Bleed area floor drain	-	-	-	-	-
Bleed conveyor blood drain	-	-	-	-	-
Bleed conveyor wash drain	250	5.5	2.5	0.004	0.1
Dehair floor drain + scald tank	1100	933.0	423.2	0.649	17.0
Resin stripper	65	6.8	3.1	0.005	0.1
Rail polisher drain	120	12.8	5.8	0.009	0.2
"660" grease drain	120	30.8	14.0	0.021	0.6
Carcass shower	(25)	(6.0)	(2.7)	(0.004)	(0.1)
Center grease drain	275	47.4	21.5	0.033	0.9
"330" grease drain	630	123.7	56.1	0.086	2.2
Head washer	-	-	-	-	-
Stomach washer	1660	964.5	437.5	0.671	17.5
Washer washer drain	5290	3374.9	1530.8	2.346	61.4
Neck washer	(6390)	(680)	(308)	(0.472)	(12.3)
Total	——	5499.4	2494.5	3.828	100%

TABLE 8-5

INITIAL CHARACTERIZATION OF THE HOG SLAUGHTERING FLOOR
(PRODUCTION SHIFT) FOR THE MADISON PLANT

TOTAL VOLATILE SOLIDS SUMMARY

Sample point	mg/l	Pounds/ shift	Kilograms/ shift	Pounds/ 1000 lb LWK	Percent of load
Bleed area floor drain	-	-	-	-	-
Bleed conveyor blood drain	-	-	-	-	-
Bleed conveyor wash drain	1940	45	19.5	0.030	0.5
Dehair floor drain + scald tank	1490	1260	570.3	0.875	15.0
Rosin stripper	390	41	18.5	0.028	0.5
Rail polisher drain	530	57	25.8	0.040	0.7
"640" grease drain	380	100.1	45.4	0.070	1.2
Carcass shower	(230)	(56.1)	(25.4)	(0.039)	(0.7)
Center grease drain	650	111	50.4	0.077	1.3
"330" grease drain	1200	251.3	113.9	0.175	3.0
Head washer	-	-	-	-	-
Stomach washer	2020	1174	532.7	0.817	14.0
Rasher washer drain	8420	5364.4	2433.3	3.730	63.9
Neck washer	(13700)	(1415)	(642.1)	(0.980)	(16.9)
Total	——	8403.8	3809.8	5.84	100%

TABLE A-6

INITIAL CHARACTERIZATION OF THE HOG SLAUGHTERING FLOOR (PRODUCTION SHIFT) FOR THE MADISON PLANT

GREASE SUMMARY

Sample point	mg/l	Pounds/ shift	Kilograms/ shift	Pounds/ 1000 lb LWK	Percent of load
Bleed area floor drain	No flow	-	-	-	-
Bleed conveyor blood drain	No flow	-	-	-	-
Bleed conveyor wash drain	104.43	2.3	1.01	0.003	0.1
Dehair floor drain + scald tank	306	258.4	117.2	0.180	3.4
Rosin stripper	- - - - - - - - - - - - -	- - - - - -	Negligible	- - - - - - - - - -	- - - - - - - - -
Rail polisher drain	67	7.2	3.3	0.005	0.1
"660" grease drain	64	16.8	7.6	0.012	0.2
Carcass shower	-	-	-	-	-
Center grease drain	64	11.0	5.0	0.008	0.1
"330" grease drain	541	106.3	48.2	0.074	1.4
Head washer	-	-	-	-	-
Stomach washer	3620	2092	948.9	1.454	27.3
Hasher washer drain	8099	5162	2341	3.590	67.4
Neck washer	(21142)	(2183.1)	(990.2)	(1.518)	(28.5)
Total	———	7656	3472.2	5.325	100%

TABLE A-7

INITIAL CHARACTERIZATION OF THE HOG SLAUGHTERING FLOOR
(PRODUCTION SHIFT) FOR THE MADISON PLANT

KJELDAHL NITROGEN SUMMARY

Sample point	mg/l	Pounds/ shift	Kilograms/ shift	Pounds/ 1000 lb LWK	Percent of load
Bleed area floor drain	-	-	-	-	-
Bleed conveyor blood drain	-	-	-	-	-
Bleed conveyor wash drain	270	6.3	2.9	0.004	0.8
Dehair floor drain + scald tank	220	188.5	85.5	0.131	24.4
Rosin stripper	30	3.3	1.5	0.002	0.4
Rail polisher drain	62	6.6	3.0	0.005	0.8
"660" grease drain	105	27.2	12.3	0.019	3.5
Carcass shower	(50)	(11.5)	(5.2)	(0.008)	(1.5)
Center grease drain	380	64.5	29.3	0.045	8.4
"330" grease drain	415	80.3	36.4	0.056	10.4
Head washer	-	-	-	-	-
Stomach washer	100	59.0	26.8	0.041	7.6
Hasher washer drain	530	336.2	152.5	0.23	43.5
Jack washer	(340)	(35.7)	(16.2)	(0.02)	(4.6)
Total	——	771.9	350.2	0.533	100%

TABLE A-6

INITIAL CHARACTERIZATION OF THE HOG SLAUGHTERING FLOOR (PRODUCTION SHIFT) FOR THE MADISON PLANT

BOD-5 SUMMARY

Sample point	mg/l	Pounds/ shift	Kilograms/ shift	Pounds 1000 lb LWK	Percent of load
Bleed area floor drain	-	-	-	-	-
Bleed conveyor blood drain	-	-	-	-	-
Bleed conveyor wash drain	920	20.5	9.3	0.014	0.4
Dehair floor drain + scald tank	915	771.	349.9	0.536	13.2
Rosin stripper	120	12.6	5.7	0.009	0.2
Bell polisher drain	260	28.2	12.8	0.020	0.5
"660" grease drain	205	53.8	24.4	0.037	1.0
Carcass shower	(60)	(13.7)	(6.2)	(0.010)	(0.2)
Center grease drain	210	35.7	16.2	0.025	0.6
"330" grease drain	1240	242.6	110.1	0.165	4.2
Head washer	-	-	-	-	-
Stomach washer	1330	772.5	350.4	0.537	13.3
Washer washer drain	6090	3883.	1761.	2.70	66.8
Neck washer	(5810)	(517.)	(234.)	(0.36)	(9.9)
Total	———	5819.3	2639.6	4.047	100%

TABLE 8-3

INITIAL CHARACTERIZATION OF THE HOG SLAUGHTERING FLOOR
(PRODUCTION SHIFT) FOR THE MADISON PLANT

COD SUMMARY

Sample point	mg/l	Pounds/ shift	Kilograms/ shift	Pounds/ 1000 lb LWK	Percent of load
Bleed area floor drain	-	-	-	-	-
Bleed conveyor blood drain	-	-	-	-	-
Bleed conveyor wash drain	2360	52.5	23.8	0.036	0.4
Dehair floor drain + scald tank	2230	1882.	854.	1.308	12.8
Rosin stripper	320	34.0	15.3	0.023	0.2
Rail polisher drain	610	64.9	29.4	0.045	0.4
"666" grease drain	440	114.5	51.9	0.080	0.8
Carcass shower	(200)	(40.2)	(21.8)	(0.03)	(0.3)
Center grease drain	2830	485.0	219.8	0.337	3.3
"330" grease drain	2260	444.3	201.5	0.308	3.0
Head washer	-	-	-	-	-
Stomach washer	3220	1871.0	849.	1.300	12.7
Hasher washer drain	15340	9780.	4436.	6.800	66.4
Neck washer	(13500)	(1482.)	(635.)	(0.90)	(9.5)
Total		14728.2	6680.7	10.20	100.

TABLE B-1. WASTE WATER FLOW FROM THE MADISON PLANT CLEAN UP SHIFT

Sample point	Gallons/ shift	Liters/ shift	Gallons/ shift	Liters/ shift	Percent of flow
Bleed area floor drain	2840.00	10740.00	1.9	16.5	1.6
Bleed conveyor blood drain	1150.00	4360.00	.8	6.7	.7
Bleed conveyor wash drain	2240.00	8480.00	1.5	12.4	1.3
Dehair floor drain scald tank	94880.00	359120.00	66.0	550.2	55.6
Scald tank	(8000.00)	(30280.00)	(5.56)	(46.37)	(4.7)
Brain stripper drain	—	a	—	—	—
Ball polisher drain	—	a	—	—	—
HH Grease drain	12540.00	47470.00	8.7	72.9	7.3
Carcass shower	—	a	—	—	—
Center grease drain	—	a	—	—	—
3H Grease drain	16420.00	62150.00	11.4	95.2	9.6
Head washer drain	—	a	—	—	—
Stomach washer	5150.00	19490.00	3.6	29.9	3.0
Washer washer drain	35660.00	134980.00	24.8	205.5	20.9
Neck washer	—	a	—	—	—
Total	170760.00	646370.00	118.7	990.6	100.00%

[a] No flow during the clean up shift.

TABLE B-1. TOTAL SOLIDS FROM THE MADISON PLANT CLEAN UP SHIFT

	lb/shift	kg/shift	lb/1000 lb LWK	Percent of load
Blood area floor drain	44.4	20.1	.031	0.90
Blood conveyor blood drain	21.6	9.8	.015	0.40
Blood conveyor wash drain	27.9	12.6	.019	0.60
Dehair floor drain	724.2	328.5	.504	15.2
Scald tank	(323.8)	(146.9)	(.226)	(6.51)
Rosin stripper drain	a	—	—	—
Bell polisher drain	a	—	—	—
660 Grease drain	177.7	80.6	.124	3.7
Carcass shower	a	—	—	—
Center grease drain	b	—	—	—
330 Grease drain	3582.	1625	2.488	75.4
Head washer drain	a	—	—	—
Stomach washer	27.2	12.3	.019	0.6
Hasher washer drain	150.3	68.2	.105	3.2
Neck washer	a	—	—	—
Total	4757.2	2161.1	3.314[b]	100.00%

[a] No flow during the clean up shift.

[b] lb/1000 lb LWK = kg/1000 kg LWK.

TABLE 9-3. TOTAL VOLATILE SOLIDS FROM THE MADISON PLANT CLEAN UP SHIFT

Sample point	lb/shift	kg/shift	lb/1000 lbLWK	Percent of load
Blood area floor drain	32.8	14.9	.023	4.8
Blood conveyor blood drain	16.2	7.3	.011	2.4
Blood conveyor wash drain	11.0	5.0	.008	1.6
Dehair floor drain	374.	170.	.26	55.2
Scald tank	(152.7)	(69.3)	(.106)	(22.5)
Brain stripper drain	a	—	—	—
Bell polisher drain	a	—	—	—
660 Grease drain	46.5	21.1	.032	6.9
Carcass shower	a	—	—	—
Center grease drain	a	—	—	—
330 Grease drain	127.4	57.8	.089	18.8
Head washer drain	a	—	—	—
Stomach washer	15.5	7.0	.011	2.3
Barber washer drain	54.4	24.7	.038	8.0
Neck washer	a	—	—	—
Total	677.8	307.8	.472	100.00%

[a] No flow during the clean up shift.

TABLE B-4. SUSPENDED SOLIDS FROM THE MADISON PLANT CLEAN UP SHIFT

Sample point	lbs/shift	kg/shift	lb/1000 lbLWK	Percent of load
Bleed area floor drain	12.7	5.8	.009	2.0
Bleed conveyor blood drain	5.7	2.6	.004	.9
Bleed conveyor wash drain	3.5	1.6	.002	.6
Dehair floor drain	355.2	161.1	.247	56.7
Scald tank	(151.7)	[illegible]	(.105)	(24.2)
Rosin stripper drain	a	—	—	—
Ball polisher drain	a	—	—	—
660 Grease drain	27.8	12.6	.019	4.4
Carcass shower	a	—	—	—
Center grease drain	a	—	—	—
350 Grease drain	165.4	75.0	.115	26.4
Head washer drain	a	—	—	—
Paunch washer	9.2	4.2	.006	1.5
Hasher washer drain	47.0	21.3	.033	7.5
Neck washer	a	—	—	—
Total	626.5	284.2	.435	100.00%

[a] No flow during the clean up shift.

TABLE B-6. VOLATILE SUSPENDED SOLIDS FROM THE MADISON PLANT CLEAN UP SHIFT

Sample point	lbs/shift	kg/shift	lb/1000 lbLWK	Percent of load
Bleed area floor drain	11.2	5.1	.008	3.2
Bleed conveyor blood drain	4.4	2.0	.003	1.2
Bleed conveyor wash drain	1.7	.8	.001	.5
Dehair floor drain	212.7	96.5	.148	61.0
Scald tank	(76.06)	(34.1)	(.052)	(21.4)
Rosin stripper drain	a	—	—	—
Bell polisher drain	a	—	—	—
661 Grease drain	15.3	6.9	.011	4.4
Carcass shower	a	—	—	—
Center grease drain	a	—	—	—
330 Grease drain	75.4	34.2	.052	21.6
Head washer drain	a	—	—	—
Stomach washer	8.2	3.7	.006	2.3
Washer washer drain	20.5	9.3	.014	5.9
Neck washer	a	—	—	—
Total	348.4	158.5	.243	100.00%

[a] No flow during the clean up shift.

TABLE D-6. GREASE SUMMARY FROM THE MADISON PLANT CLEAN UP SHIFT

Sample point	mg/l	lb/shift	kg/shift	lb/1000 lb LWK	kg/1000 kg LWK	Percent of load
Bleed area floor drain	—	13.6	6.2	.009	.009	9.4
Bleed conveyor blood drain	—	1.9	.8	.001	.001	1.2
Bleed conveyor wash drain	—	.3	.2	.001	.001	.3
Dehair floor drain	—	31.41	14.2	.022	.022	21.4
Scald tank	—	(13.4)	(6.1)	(.009)	(.009)	(9.2)
Resin stripper drain	—	—	—	—	—	—
Nail polisher drain	—	—	—	—	—	—
660 Grease drain	146.20	14.6	6.6	.010	.010	10.0
Carcass shower	—	—	—	—	—	—
Center grease drain	—	—	—	—	—	—
330 Grease drain	678.80	66.1	30.0	.046	.046	45.2
Head washer drain	—	—	—	—	—	—
Stomach washer	—	10.0	4.5	.007	.007	6.8
Hasher washer drain	—	8.42	3.8	.006	.006	5.7
Neck washer	—	—	—	—	—	—
Total		146.33	66.3	.102		100.0%

TABLE 9-7. TOTAL KJELDAHL NITROGEN FROM THE MADISON PLANT CLEAN UP SHIFT

Sample point	lbs/shift	kg/shift	lb/1000 lbLWK	Percent of load
Blood area floor drain	5.8	2.6	.004	15.9
Hided conveyor blood drain	1.3	.6	.001	3.6
Blood conveyor wash drain	.7	.3	.0005	1.9
Dehair floor drain	22.7	10.3	.016	62.4
Scald tank	(21.7)	(9.83)	(.015)	(58.6)
Rosin stripper drain	a	—	—	—
Rail polisher drain	a	—	—	—
[illegible] Grease drain	3.0	1.4	.002	8.2
Carcass shower	a	—	—	—
Center grease drain	a	—	—	—
[illegible] Grease drain	1.1	.5	.001	3.0
Head washer drain	a	—	—	—
Stomach washer	.2	.1	.0001	.6
Hasher washer drain	1.6	.7	.001	4.4
Neck washer	a	—	—	—
Total	36.4	16.5	.0256	100.00%

[a] No flow during the clean up shift.

TABLE D-4. BOD FROM THE MADISON PLANT CLEAN UP SHIFT

Sample point	lbs/shift	kg/shift	lb/1000 lbLWK	Percent of load
Blood area floor drain	23.6	10.7	.016	7.5
Blood conveyor blood drain	6.5	3.0	.005	2.1
Blood conveyor wash drain	1.2	.6	.001	0.4
Dehair floor drain	180.0	81.7	.125	57.2
Scald tank	(84.9)	(38.5)	(.059)	(26.9)
Resin stripper drain	—	—	—	—
Bell polisher drain	—	—	—	—
600 Grease drain	20.5	9.3	.014	6.5
Carcass shower	—	—	—	—
Center grease drain	—	—	—	—
330 Grease drain	65.7	29.8	.046	20.9
Head washer drain	—	—	—	—
Stomach washer	7.2	3.2	.005	2.3
Ruffle washer drain	9.7	4.4	.007	3.1
Neck washer	—	—	—	—
Total	314.4	142.7	.219	100.0%

TABLE B-9. COD FROM THE MADISON PLANT CLEAN UP SHIFT

Sample point	lb/shift	kg/shift	lb/1000 lbLWK	Percent of load
Bleed area floor drain	40.0	18.1	.0278	4.9
Bleed conveyor blood drain	18.18	8.24	.01264	2.2
Bleed conveyor wash drain	8.1	3.6	.0056	1.0
Dehair floor drain	543.00	246.00	.377	66.2
Scald tank	(228.6)	(103.7)	(.158)	(27.7)
Resin stripper drain	—	—	—	—
Rail polisher drain	—	—	—	—
650 Grease drain	64.5	29.2	.045	7.9
Carcass shower	—	—	—	—
Center grease drain	—	—	—	—
180 Grease drain	99.7	45.2	.0690	12.1
Head washer drain	—	—	—	—
Stomach washer	16.1	7.3	.011	2.0
Hasher washer drain	31.8	14.3	.021	3.8
Neck washer	—	—	—	—
Total	820.58	371.64	.5702	100.00%

APPENDIX C. DATA FOR TOTAL DAY (PRODUCTION PLUS CLEANUP)

TABLE C-1. WASTEWATER FLOW FROM THE MADISON PLANT PRODUCTION AND CLEANUP SHIFTS

Sample point	Gallons/ shift	Liters/ shift	Gallons/ 1000 lb LWK	Liters/ 1000 kg LWK	Percent of flow
Bleed area floor drain	2840	10740	1.9	16.5	0.5
Bleed conveyor blood drain	1150	4352	.8	6.7	0.2
Bleed conveyor wash drain	4810	18208	3.4	27.9	0.9
Dehair floor drain	195980	741769	136.3	1136.8	37.6
Scald tank	(8000)	(30280)	(5.56)	(46.4)	(1.5)
Hide stripper drain	12490	47275	8.6	72.5	2.4
Rail polisher drain	12800	48440	8.9	74.3	2.5
660 Grease drain	43970	166430	30.6	255.2	8.4
Carcass shower	28850	109200	(20.1)	(167.4)	(5.5)
Center grease drain	20580	77940	14.3	119.3	3.9
330 Grease drain	39940	151174	27.8	231.8	7.7
Head washer drain	(6520)	(24680)	(4.5)	(37.8)	(1.2)
Stomach washer	74830	283230	52.1	434.3	14.4
Washer washer drain	112100	424290	78.0	650.4	21.5
Neck washer	(12380)	(46870)	(8.6)	(71.8)	(2.4)
Total	521500	1973818	362.7	3025.7	100.00

TABLE C-2. TOTAL SOLIDS FROM THE MADISON PLANT PRODUCTION AND CLEANUP SHIFTS

Sample point	lbs/shift	kg/shift	lb/1000 lb LWK	Percent of load
Blood area floor drain	45	20.1	0.031	0.3
Blood conveyor blood drain	22	9.8	0.015	0.1
Blood conveyor wash drain	78	36.2	0.055	0.5
Dehair floor drain	2484	1127.5	1.729	16.2
Scald tank	(310.8)	(140.9)	(0.216)	(2.0)
Brain stripper drain	77	35.1	0.054	0.5
Rail polisher drain	99	45	0.069	0.7
660 Grease drain	373	169	0.260	2.4
Carcass shower	(133)	(60.1)	(0.092)	(0.9)
Center grease drain	127	57.6	0.088	0.8
330 Grease drain	4210	1910.0	2.928	27.4
Head washer drain	—[a]	—	—	—
Stomach washer	1438	653.2	1.002	9.4
Washer washer drain	6392	2898.2	4.445	41.7
Neck washer	(1470)	(666.5)	(1.02)	(9.6)
Total	15346	6962.3	10.674[b]	100.00%

[a] The pollutant load from the head washer is included in the 330 grease drain.

[b] lb/1000 lb LWK = kg/1000 kg LWK.

TABLE C-1. TOTAL VOLATILE SOLIDS FROM THE MADISON PLANT PRODUCTION AND CLEANUP SHIFTS

Sample point	lbs/shift	kg/shift	lb/1000 lb LWK	Percent of load
Bleed area floor drain	55	24.9	.037	0.6
Bleed conveyor blood drain	16	7.3	.011	0.2
Bleed conveyor wash drain	54	24.5	.038	0.6
Dehair floor drain	1634	740.3	1.135	18.0
Scald tank	(208)	(94.3)	(.136)	(1.7)
Rosin stripper drain	41	18.5	.028	0.4
Ball polisher drain	57	25.8	.040	0.6
660 Grease drain	147	66.5	.102	1.6
Carcass shower	(56.1)	(25.4)	(.039)	(.6)
Center grease drain	111	50.4	.077	1.2
330 Grease drain	379	171.7	.264	4.2
Head washer drain	a	—	—	—
Stomach washer	1190	540	.829	13.1
Gusher washer drain	5420	2459	3.68	58.7
Neck washer	(2425)	(942)	.980	(15.6)
Total	9294	4217.3	6.324[b]	100.00%

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[a] The pollutant load from the head washer is included in the 330 grease drain.

[b] lb/1000 lb LWK = kg/1000 kg LWK.

TABLE C-4. SUSPENDED SOLIDS FROM THE MADISON PLANT PRODUCTION AND CLEANUP SHIFTS

Sample point	lbs/shift	kg/shift	lb/1000 lb LWK	Percent of load
Bleed area floor drain	12.7	5.8	.005	0.2
Bleed conveyor blood drain	5.7	2.6	.004	0.1
Bleed conveyor wash drain	9.0	4.1	.006	0.1
Dehair floor drain	1288.0	584.0	.896	21.0
Scald tank	(152.7)	(69.3)	(.106)	(2.5)
Drain stripper drain	6.8	3.1	.005	0.1
Bell polisher drain	12.8	5.8	.009	0.2
660 Grease drain	58.6	26.6	.040	1.0
Carcass shower	(6.0)	(2.7)	(.004)	(.10)
Center grease drain	47.4	21.5	.033	0.8
330 Grease drain	289.1	131	.201	4.7
Head washer drain	a	—	—	—
Stomach washer	973.7	441.7	.677	15.9
Hasher washer drain	3421.9	1552.1	2.379	55.9
Neck washer	(660)	(300)	(.472)	(11)
Total	6125.7	2778.3	4.259[b]	100.00

[a] The pollutant load from the head washer is included in the 330 grease drain.

[b] lb/1000 lb LWK = kg/1000 kg LWK.

TABLE C-6. VOLATILE SUSPENDED SOLIDS FROM THE MADISON PLANT PRODUCTION AND CLEANUP SHIFTS

Sample point	lbs/shift	kg/shift	lb/1000 lb LWK	Percent of load
Bleed area floor drain	11.2	5.1	.008	0.2
Bleed conveyor blood drain	4.4	2.0	.003	0.1
Bleed conveyor wash drain	6.4	2.9	.004	0.1
Dehair floor drain	1048	475.	.728	21.1
Scald tank	(76.1)	(34.5)	(.053)	(1.5)
Brain stripper drain	5.9	2.7	.004	0.1
Rail polisher drain	12.2	5.5	.008	0.2
660 Grease drain	41.4	18.7	.029	0.8
Carcass shower	(5.2)	(2.4)	(.004)	(0.1)
Center grease drain	42.1	19.1	.029	0.8
330 Grease drain	190.	86.2	.132	3.8
Head washer drain	a	—	—	—
Stomach washer	879.	398.7	.611	17.7
Hasher washer drain	2716.	1232.	1.887	54.8
Neck washer	(635)	(288.)	(.441)	(12.8)
Total	4956.6	2247.9	3.443[b]	100.00

[a] The pollutant load from the head washer is included in the 330 grease drain.

[b] lb/1000 lb LWK = kg/1000 kg LWK.

TABLE C-6. GREASE FROM THE MADISON PLANT PRODUCTION AND CLEANUP SHIFTS

Sample point	lbs/shift	kg/shift	lb/1,000 lb LWK	Percent of load
Bleed area floor drain	13.6	6.2	.009	0.2
Bleed conveyor blood drain	1.9	.9	.001	0.1
Bleed conveyor wash drain	2.6	1.2	.002	0.1
Dehair floor drain	289.81	131.4	.202	3.7
Scald tank	(13.4)	(6.1)	(.009)	(0.2)
Rosin stripper drain	c	—	—	—
Bell polisher drain	7.2	3.3	.005	0.1
660 Grease drain	31.4	14.2	.022	0.4
Carcass shower	d	—	—	—
Center grease drain	11.0	5.0	.008	0.1
330 Grease drain	172.4	78.2	.120	2.2
Head washer drain	a	—	—	—
Stomach washer	2102.0	953.4	1.462	26.9
Hasher washer drain	5170.4	2344.1	3.596	66.3
Neck washer	e	—	—	—
Total	7802.01	3537.8[b]	5.427[b]	100.00

[a] The pollutant load from the head washer is included in the 330 grease drain.
[b] lb/1000 lb LWK = kg/1000 kg LWK.
[c] The rosin stripper has a negligible grease contribution.
[d] The carcass shower grease load is included in the 660 grease drain.
[e] The neck washer grease is included in the hasher washer.

TABLE C-7. TOTAL KJELDAHL NITROGEN FROM THE MADISON PLANT PRODUCTION AND CLEANUP SHIFTS

Sample point	lbs/shift	kg/shift	lb/1000 lb LWK	Percent of load
Bleed area floor drain	5.8	2.6	.004	0.7
Bleed conveyor blood drain	1.3	.6	.001	0.2
Bleed conveyor wash drain	7.0	3.2	.005	0.9
Dehair floor drain	211.2	95.8	.147	26.1
Scald tank	(21.7)	(9.8)	(.015)	(2.7)
Brain stripper drain	3.3	1.5	.002	0.4
Nail polisher drain	6.6	3.0	.005	0.8
660 Grease drain	30.2	13.7	.021	3.7
Carcass shower	(11.5)	(5.2)	(.008)	(1.4)
Cutter grease drain	64.5	29.3	.045	8.0
330 Grease drain	81.4	36.9	.057	10.1
Head washer drain	a	—	—	—
Stomach washer	59.2	26.9	.041	7.3
Hasher washer drain	337.8	153.2	.235	41.8
Neck washer	(35.7)	(16.2)	(.025)	(4.4)
Total	808.1	366.7	.561[b]	100.0

[a] The pollutant load from the head washer is included in the 330 grease drain.

[b] lb/1000 lb LWK = kg/1000 kg LWK.

TABLE C-8. BOD_5 FROM THE [illegible] PLANT PRODUCTION AND CLEANUP SHIFTS

Sample point	lb/shift	kg/shift	lb/1000 lb LWK	Percent of load
Blood area floor drain	23.6	10.7	.016	.4
Blood conveyor blood drain	6.5	3.0	.005	.1
Blood conveyor wash drain	21.7	9.9	.015	.4
Dehair floor drain	951	431.6	.661	15.5
Scald tank	(84.9)	(38.5)	(.059)	(1.4)
Rosin stripper drain	12.6	5.7	.009	.2
Ball polisher drain	28.2	12.8	.020	.5
660 Grease drain	74.3	33.7	.051	1.2
Carcass shower	13.71	(6.2)	(.010)	(0.2)
Center grease drain	35.7	16.2	.025	.6
330 Grease drain	308.3	139.8	.215	5.0
Head washer drain	a	—	—	—
Stomach washer	779.7	353.6	.542	12.7
Hasher washer drain	3892.	1765.4	2.707	63.4
Neck washer	(51.7)	(23.4)	(.036)	(0.8)
Total	6138.6	2782.5	4.266[b]	100.00

---

[a] The pollutant load from the head washer is included in the 330 grease drain.

[b] lb/1000 lb LWK = kg/1000 kg LWK.

TABLE C-4. COD FROM THE MADISON PLANT PRODUCTION AND CLEANUP SHIFTS

Sample point	lbs/shift	kg/shift	lb/1000 lb LWK	Percent of load
Blood area floor drain	40.	18.1	.027	.3
Blood conveyor blood drain	18.2	8.2	.013	.1
Blood conveyor wash drain	60.6	27.4	.042	.4
Dehair floor drain	2425.	1100.	1.685	15.6
Scald tank	(228.5)	(103.7)	(.158)	(1.5)
Rosin stripper drain	34.2	15.3	.023	.2
Bell polisher drain	64.9	29.4	.045	.4
660 Grease drain	179.	81.1	.125	1.2
Carcass shower	(48.2)	(21.8)	(.033)	(0.3)
Center grease drain	485.	219.8	.337	3.1
330 Grease drain	544.	246.7	.380	3.5
Head washer drain	a	—	—	—
Stomach washer	1887.	856.3	1.315	12.1
Hasher washer drain	9811.	4450	6.821	63.1
Neck washer	(2402)	(835)	(.900)	(5.8)
Total	15548.7	7052.3	10.832[b]	100.00

[a] The pollutant load from the head washer is included in the 330 grease drain.

[b] lb/1000 lb LWK = kg/1000 kg LWK.

APPENDIX D. CORRELATION OF PARAMETERS

The cost of conducting a wastewater survey increases rapidly as more pollution parameters are measured. It may fortunately happen that one measure of pollution correlates strongly with another. Then the survey could eliminate some measures without sacrificing information. Linear correlations between parameters were examined to see if this could be done in future surveys. Of particular interest are possibilities for eliminating the BOD or COD measurement and to use Kjeldahl nitrogen as a summarizing parameter.

The idea is illustrated with data from the hasher washer. This is a major source of pollution. Figures D-1 through D-5 show the relation between BOD and COD, BOD and Total Carbon, BOD and Organic Carbon, BOD and suspended solids, and BOD and Kjeldahl nitrogen. A good linear relation is evident. Calculated linear relations and correlation coefficients are given in Table D-1.

Table D-1. HASHER WASHER CORRELATIONS

Relation	Correlation Coefficient	Number of Data
BOD = 1121 + 0.35 COD	0.82[a]	24
BOD = 298 + 1.55 (Total Carbon)	0.83	24
BOD = 630 + 1.33 (Organic Carbon)	0.84	24
BOD = 1645 + 0.86 (Suspended Solids)	0.71	24
BOD =-1604 + 14.6 (Total Kjeldahl Nitrogen)	0.85	24

[a] All these correlations are significant at the 99% confidence level.

The correlation coefficient indicates the strength of the relationship between the two variables. The square of the correlation coefficient, in the case of the BOD-COD relation ($0.82^2 = 0.67$), indicates the fraction of the variation of the dependent variable explained by the independent variable; COD explains 67% of the variation in BOD. The fraction that is not accounted for by the linear relation is experimental error; that is, unavoidable variations in sampling and analytical methods.

The conclusion drawn from this analysis is that the hasher washer drain discharge could be characterized equally well by BOD, COD, Total Kjeldahl Nitrogen, or the carbon measurements.

Of greatest interest is the nitrogen correlation. A nitrogen

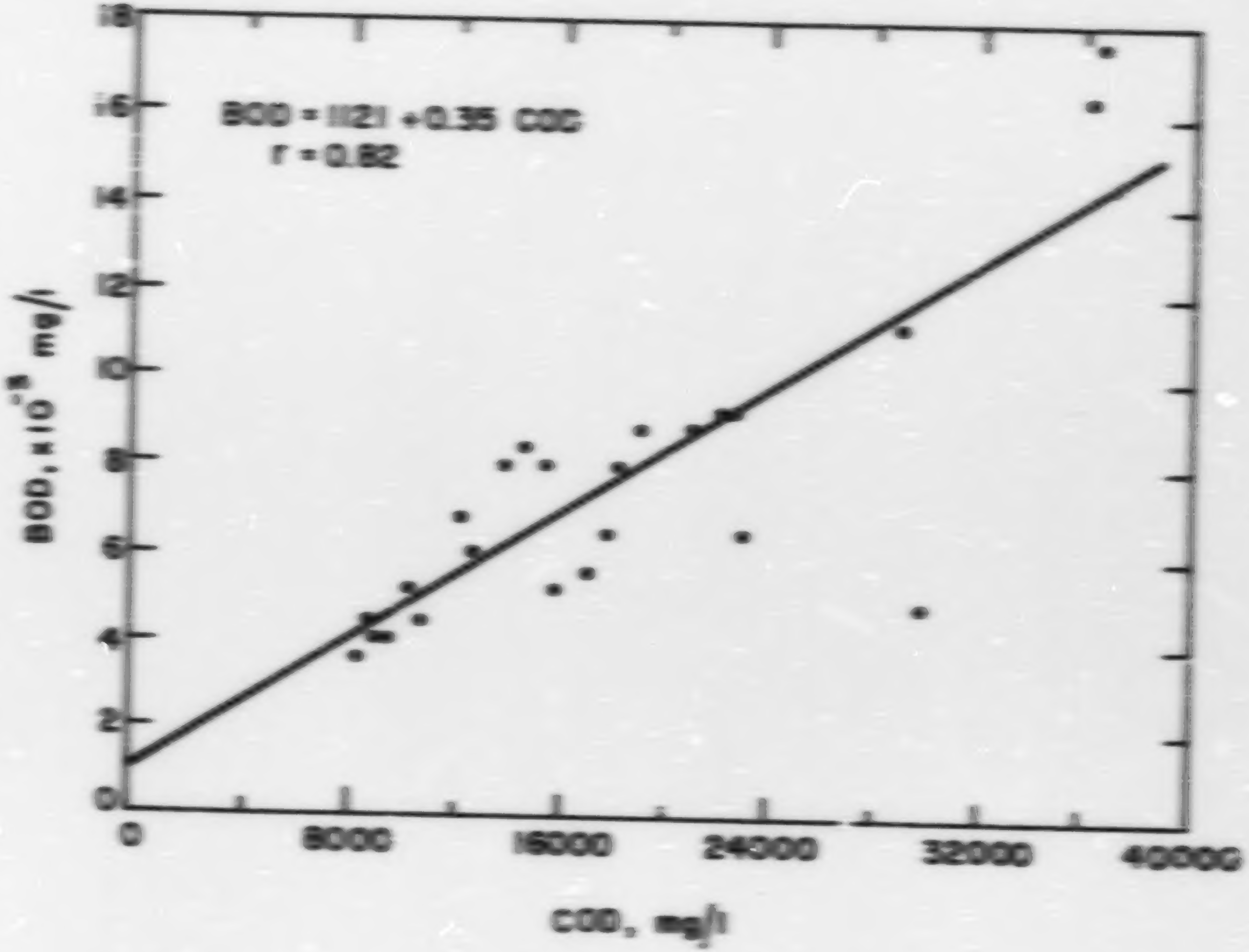

Figure 3-1. Correlation of BOD-COD in [illegible] water.

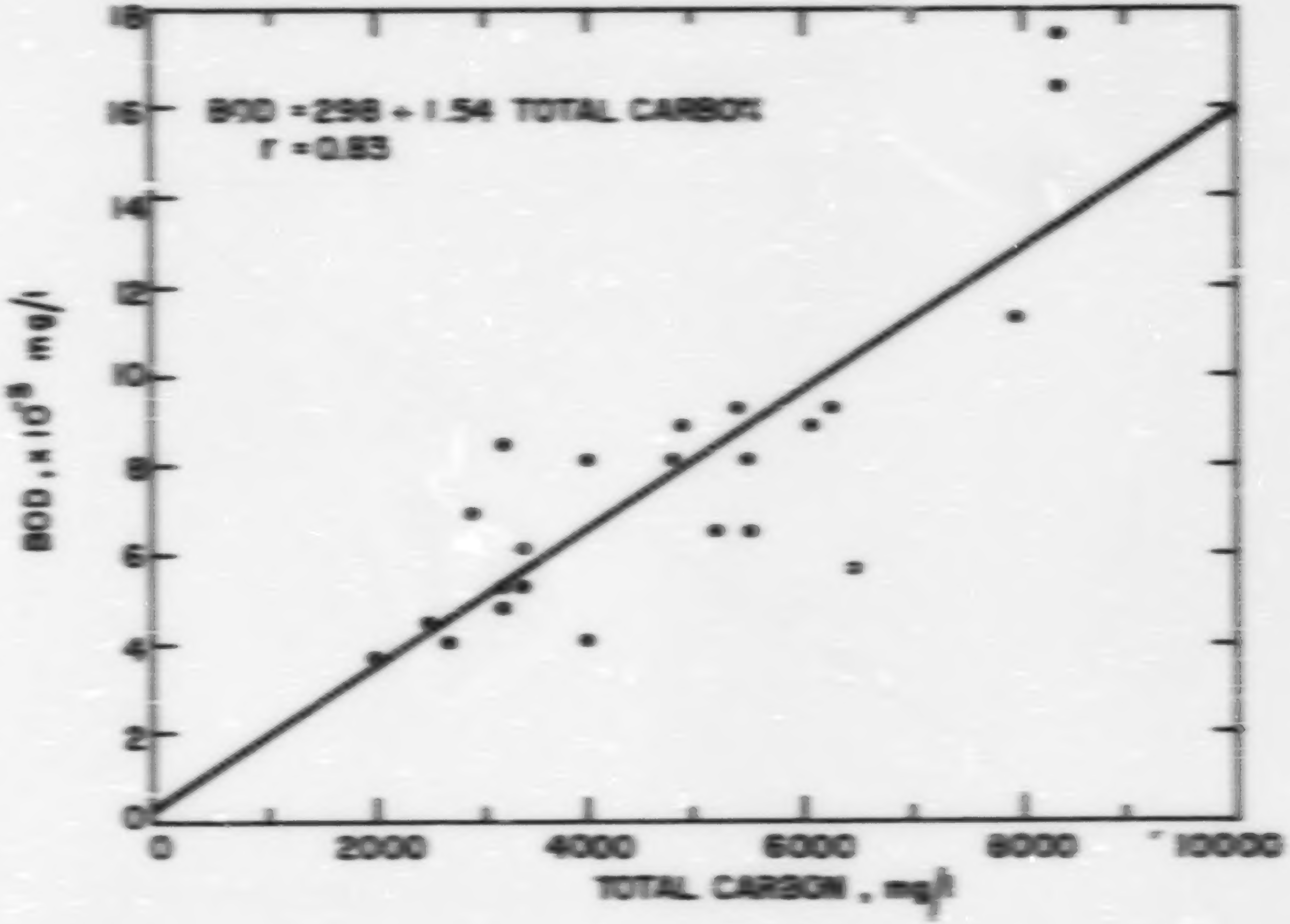

Figure 3-2. Correlation of BOD-Total Carbon at leather washers.

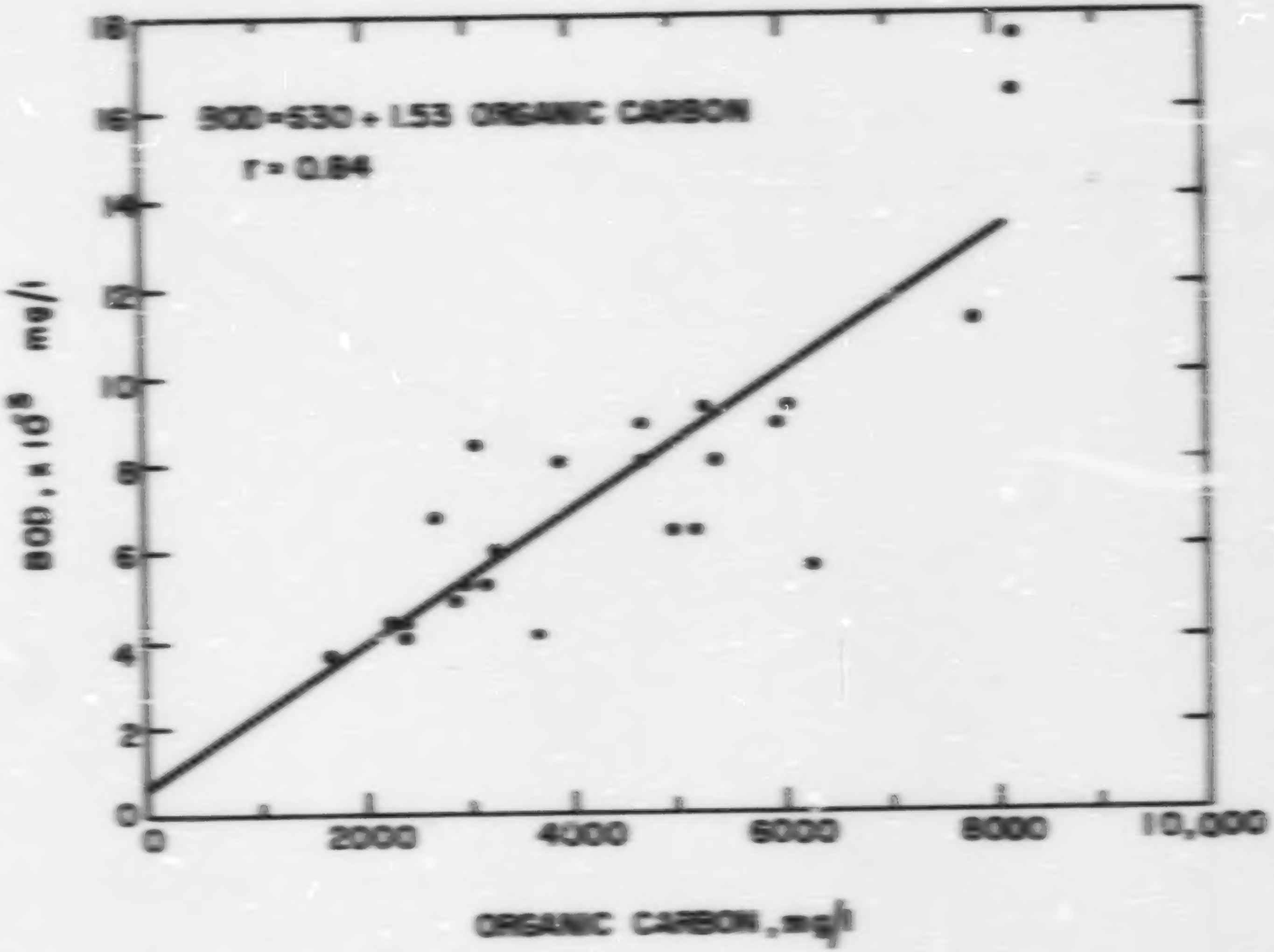

Figure 3-1. Correlation of BOD-Organic Carbon at [illegible] washer.

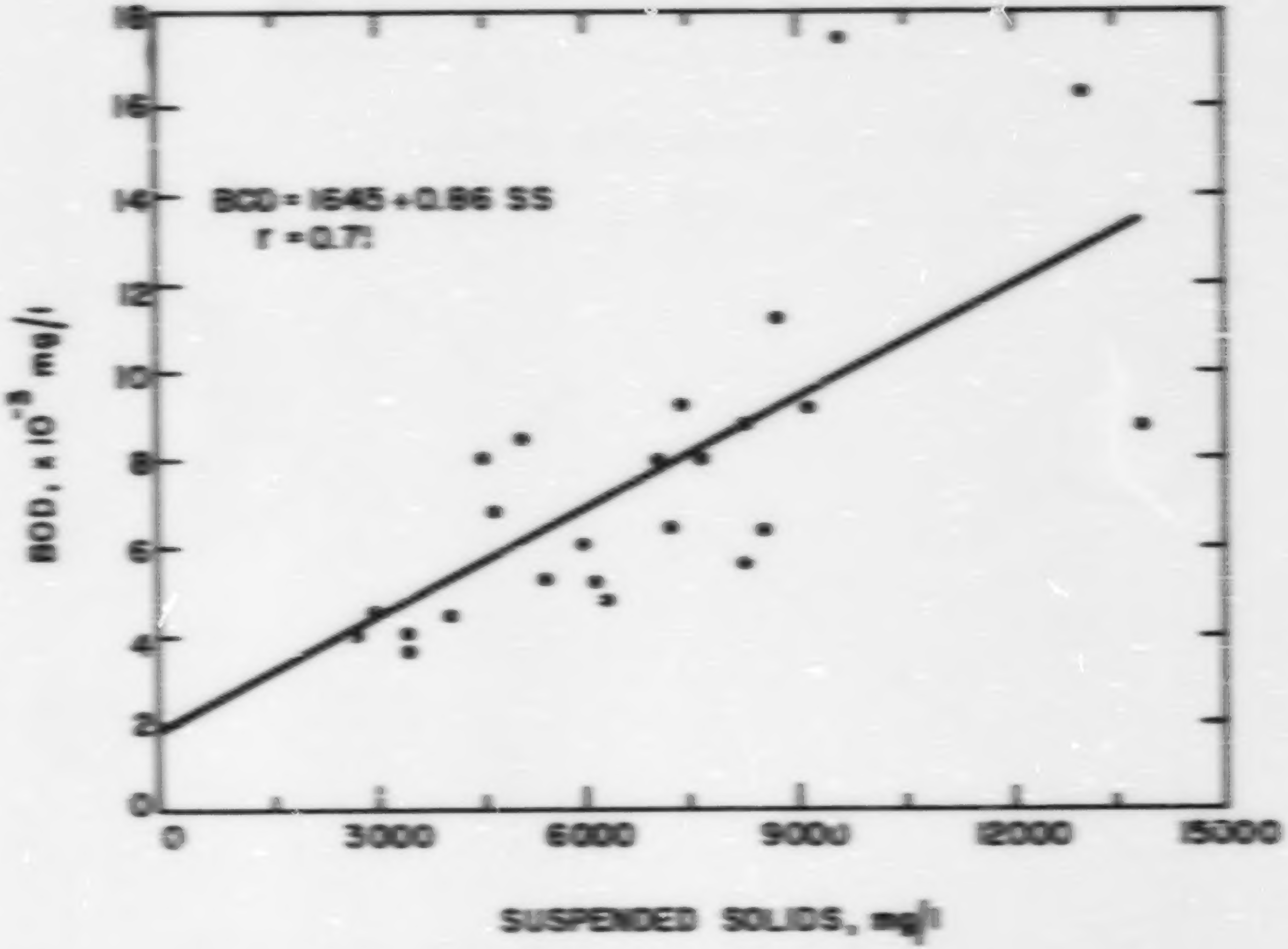

Figure 3-4. Correlation of BOD-Suspended Solids at [illegible] [illegible].

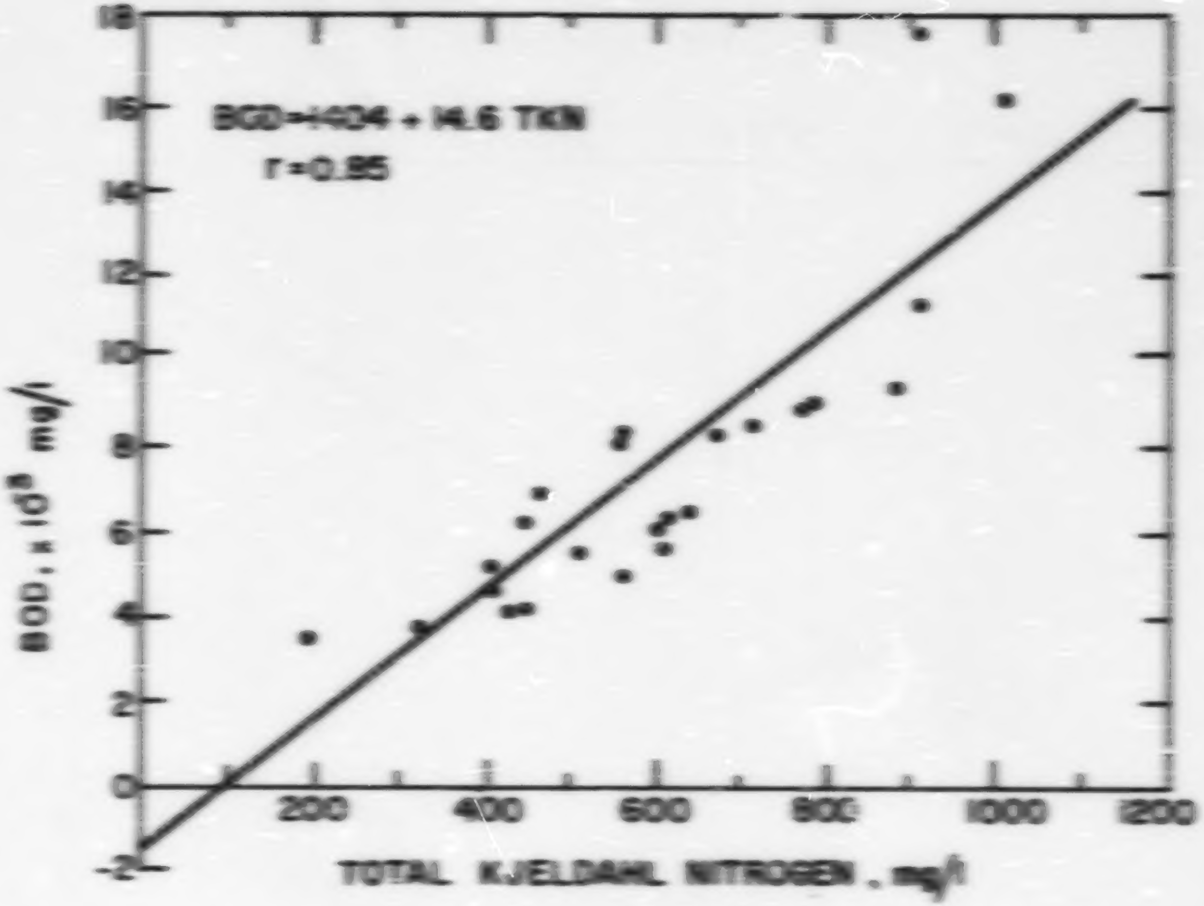

Figure 3-5. Correlation of BOD-TKN at [illegible] water.

measurement indicates both nitrogen and BOD and is, therefore, an attractive and efficient parameter for wastewater characterization. Meat industry wastes contain large amounts of proteinaceous matter, apparently, in concentrations that are a consistent proportion of the total organic matter measured as organic carbon or carbonaceous oxygen demand. Table D-2 summarizes these relations. The three stations having low correlations produced a few erratic data points for which there is insufficient justification for total rejection.

This nitrogen measurement is very informative because from it one can infer usable values for other parameters at most stations. Most meat industries have the capability to measure TKN; they may not be equipped to do the BOD, COD, or Total Carbon tests. The TKN test, therefore, becomes a good screening tool for the first in-house pollution survey.

Suspended solids is also a useful surrogate even though the correlation is slightly less.

Table D-3 shows BOD prediction equations for the thirteen sampling points in the Madison plant. The correlation for the center grease drain is not significant. The correlation coefficients of those relations that are significant are very high.

The two parameters of each equation are the slope and the intercept. The value of the intercept depends on the strength of the waste at a particular location while the slope depends on the nature of the organics in the waste and their relative biodegradability. In four cases the intercept is positive even though it is well known that the COD of a waste is always greater than the BOD. This happens because the intercept obtained by extrapolation is far beyond the range of the actual data. The intercept is a fitting parameter without any physical significance.

If the wastewater from each station contains the same proportion of biodegradable organics to chemically oxidizable organics, the slopes would all be the same (within some reasonable range). The slopes for the blood conveyor wash drain and the neck washer are noticeably different than the others. The blood conveyor wash drain waste is very dilute and the pollutant is blood. The neck washer wastewater contains substantial amounts of fatty tissue and this may be the reason the BOD at this station represents a greater fraction of the COD than at other stations.

Table D-2. BOD-TKN CORRELATIONS

Sample point	Relation	r	n
Blood area floor drain	BOD = 33 + 4.6 TKN	0.84	13
Blood Area blood drain	BOD = -188.4 + 4.2 TKN	0.97	12
Chain wash	BOD = 0.67 + 1.8 TKN	0.97	25
Dehair floor drain	BOD = 37.6 + 4.28 TKN	0.86	44
Rosin stripper	BOD = -43 + 3.79 TKN	0.98	5
Rail polisher	BOD = -11.9 + 4.4 TKN	0.90	13
660 grease drain	BOD = 179 + 0.238 TKN	0.49	41
Carcass shower	a		18
Center grease drain	BOD = 38 + 0.45 TKN	0.83	11
330 grease drain	a		24
Stomach washer	a		11
Hasher washer	BOD = -1404 + 14.6 TKN	0.85	24
Neck washer	BOD = 2626 + 6.8 TKN	0.86	16

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[a] Insignificant correlation.

Table D-3. CORRELATION VALUES BETWEEN PARAMETERS [illegible] DURING THE STUDY

Sample point	Prediction equation	Correlation coefficient	Sample size	Significant at 95% level?
Bleed area floor drain	BOD = −135 + 0.53 COD	0.98	15	yes
Bleed conveyor blood drain	a	a	—	—
Bleed conveyor wash drain	BOD = 20 + 0.23 COD	0.93	25	yes
Dehair floor drain	BOD = 109 + 0.32 COD	0.90	60	yes
Resin stripper drain	BOD = −3.7 + 0.38 COD	0.94	5	yes
Bell polisher drain	BOD = 40.6 + 0.36 COD	0.89	13	yes
660 grease drain	BOD = −9.7 + 0.49 COD	0.86	42	yes
Carcass shower	BOD = −30.4 + 2.29 COD	0.95	18	yes
Center grease drain	b			
330 grease drain	BOD = −8.7 + 0.54 COD	0.98	26	yes
Stomach washer	BOD = 85.1 + 0.38 COD	0.84	28	yes
Hasher washer drain	BOD = 1121 + 0.35 COD	0.82	26	yes
Neck washer	BOD = 2586 + 0.27 COD	0.76	16	yes

[a] Data insufficient to do analysis.

[b] Insignificant relation.

Table D-4 shows other correlations that bear out conclusions already drawn.

Another question that has been studied in cursory fashion is whether or not the correlations change after a change has been made. If, for example, meat scrap that once entered the drain is picked up dry, does this alter the wastewater organic fractions enough to change the slope of the regression equations? Table D-5 shows a few of the hasher washer relations derived after a substantial change in the process was made. The nature of the relation was maintained. The correlation coefficient is higher, probably, because there was less intermittent sluicing of heavy wastes into the drain. COD or TKN still seem to be attractive surrogates for BOD.

Because so much of this project was directed toward thorough characterization, it was considered better practice to collect data on many parameters throughout the project rather than to try and take advantage of correlations to alter the analytical program early in the project. Now that the project is complete and the data is at hand, it is clear that preliminary wastewater surveys in the meat industry could be based firmly on total Kjeldahl nitrogen measurements, supplemented with solids analysis and an occasional COD. Major sources of pollution would be identified quickly and reliably with minimum effort.

Table D-6. BOD PREDICTIVE [illegible] FOR THE [illegible] PRODUCTION SHIFT INITIAL CHARACTERIZATION

Sample point	Total carbon	Organic carbon	Susp. solids	TKN	n
Bleed area floor drn	$-319 + 1.38\ TC^a$ $(0.98)^b$	899 + 0.65 OC (0.65)	−56 + 2.79 SS (0.82)	32 + 4.6 TKN (0.86)	15
Bleed area blood drn	c	c	536 + 0.78 SS (0.74)	339 + 3.5 TKN (0.88)	19
Chain wash	−29.4 + 0.77 TC (0.96)	8.5 + 0.61 OC (0.95)	22.6 + 0.34 SS (0.80)	0.67 + 1.8 TKN (0.37)	25
Dehair floor drain	—	—	181 + 0.50 SS (0.86)	386 + 2.6 TKN (0.57)	62
Rosin stripper	—	—	25.8 + 2.60 SS (0.79)	−0.63 + 3.79 TKN (0.98)	5
Bell polisher	c	9.2 + 1.2 OC (0.95)	113 + 1.25 SS (0.45)	11.9 + 4.4 TKN (0.90)	13
660 Grease drain	d	d	c	178 + 0.26 TKN	42
Carcass shower	−78.4 +2.19 TC (0.96)	12.6 + 1.19 OC (0.96)	−4.37 + 2.59 SS (0.66)	c	18
Center grease drain	d	d	c	38 + 0.45 TKN (0.85)	11
130 Grease drain	c	c	383 + 1.52SS (0.87)	d	36
Stomach washer	c	c	407 + 0.55 TS (0.75)	d	28
Tucker washer	2.98 + 1.54 TC (0.85)	630 + 1.53 OC (0.86)	1645 + 0.86 SS (0.71)	−1486 + 16.6 TKN (0.85)	26
Neck washer	c	c	1086 + 1.5SS (0.90)	2626 + 6.8 TKN (0.86)	16

[a] Read: BOD = given relation.
[b] Correlation coefficient.
[c] Insufficient data.
[d] Insignificant correlation.

Table D-5. CORRELATION AT THE HASHER WASHER AFTER THE IMPROVEMENT

Relation	r	n
BOD = 433 + 0.33 COD	0.95	11
BOD = 507 + 1.05 Total carbon	0.908	11
BOD = 638 + 1.05 Organic carbon	0.908	11
BOD = 354 + 1.87 Suspended solids	0.89	11
BOD = 654 + 3.2306 TKN	0.95	11

APPENDIX E. DATA MANAGEMENT FOR AN INDUSTRIAL WASTEWATER SURVEY

I INTRODUCTION

Accurate and efficient data handling and analysis is crucial to the success of an industrial waste survey. If data is lost, or if data is misrepresented, the resulting conclusions will be weak or incorrect. The value of a well organized data handling system increases in proportion to the size of the project and the amount of data handling and analysis.

The data management program described here is not needed for small surveys. It was necessary for this project because it involved studies at three different production facilities. At the Madison plant thirteen locations were sampled on both the production and cleanup shifts, and each location was sampled on many different days. Flows and concentration parameters had to be measured and recorded. The pollution parameters routinely analyzed were:

- Total solids
- Total volatile solids
- Suspended solids
- Volatile suspended solids
- Grease
- Total Kjeldahl Nitrogen
- Organic Carbon
- Total Carbon
- Biochemical Oxygen Demand
- Chemical Oxygen Demand

Fifteen people were involved in data collection, data processing, and data analysis. Hundreds of bits of data needed to be processed and each bit of data represented a sample that had to be collected and analyzed in the laboratory. Keeping track of the samples as they were processed through the laboratory, and monitoring the data as they went to the keypunch operator and then onto magnetic tape was a major problem.

The overall data management scheme is diagrammed in Figure E-1. The stepwise procedure included data collection, laboratory analysis, data entry for computer logging, data storage, and data analysis. The production shift data and the cleanup shift data had to be analyzed differently so they will be discussed separately.

II DATA MANAGEMENT

Proper identification of each sample is important. And, the laboratory personnel must be able to see clearly which measurements are to be made on each sample. The form shown as Figure E-2 was used to

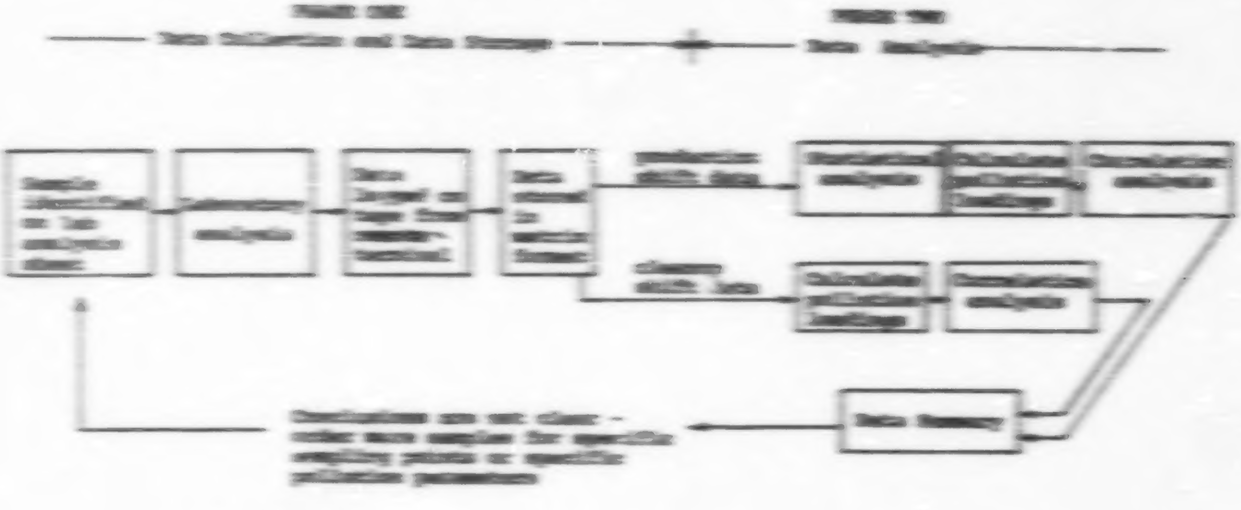
PHASE ONE
Data Collection and Data Storage
PHASE TWO
Data Analysis
Sample identified on lab analysis sheet
Laboratory analysis
Data logged on tape from remote terminal
Data stored in machine format
Historical with data
Current with data
Statistical analysis
Calculate pollutant loadings
Correlation analysis
Data Summary
Conclusions are not clear - order more samples for specific sampling points or specific pollution parameters

Figure 9-1. Process flow sheet for data management and analysis.

[illegible]

[illegible]

Sample Description: [illegible] ___
[illegible] ___
Sample Point ___

Date ___
Sampled by ___
Analyzed ___ [illegible] ___
BOD Start ___
End ___

Sample Ident.	Time	[illegible]				[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]		
Analysis Completed																

Remarks: [illegible]

[illegible]

[illegible]

Figure 5-1. Laboratory data form.

accomplish this task. The individual collecting the sample filled in the form consistent with the sample bottle labels, and marked a check under the desired analyses. One sheet is used for each sampling point and for each day of sampling.

The second step is laboratory analysis. The laboratory technician is responsible for proper care of the samples after they have been delivered to the laboratory and, obviously, for accurate analytical measurements. When the analysis is complete, he checks the "Analysis Completed" box in the bottom row of Figure E-2, and gives the completed form to the project manager. Two copies are made of the completed laboratory analysis sheet. One copy is retained in the laboratory file, one copy goes to the project manager, and the original is sent to the teletype terminal operator. It is essential that the laboratory technician fill in the form completely and legibly to avoid confusions during entry of the data onto the computer tape.

A "Lab in Progress" form was developed to control the sample inventory. This is shown as Figure E-3. It gives the project manager and the laboratory technician a method for estimating the number of samples in the laboratory and the length of time they have been there. It was also useful in planning sampling schedules.

The terminal operator enters seventeen bits of data from each line on the Laboratory Analysis Sheet. The seventeen data points entered are: the time each sample was collected, and the following sixteen columns of parameter values. The data analysis program is written in free format to minimize the instruction for the terminal operator. Plant location, date, processing area, and other geographic information from the data transmissions sheets are logged as data and eventually appear on the print out to facilitate clear and complete identification of the data. The data is put onto magnetic tape. A soft copy of the data on tape is given to the project manager who checks it for errors. Decimal point errors are obvious on the computer printout. Suspicious values also stand out and these are checked against the original data sheet. Samples are stored until this check is made in case a "wet check" is desired. Once the data file is error free, the data is transferred from the tape to cards. Some users might prefer to manipulate the tape file but in our case different computing facilities were used for different data analysis jobs, and having the data as a card deck was very convenient.

To optimize the data entry and data handling, the data was collected into groups or batches. The progress of each batch from laboratory to computer file to carddeck in the project manager's hands was monitored and controlled.

FIGURE I-3

CHARACTERIZATION AND REDUCTION OF SPECIFIC WASTEWATERS FROM IN-PLANT HOG PROCESSING UNITS OF THE MEAT INDUSTRY

Lab In-progress Inventory Sheet

Plant: Madison

Shift: Production

Sample Point	Date Recieved	No. of Samples	Data sent to Manager
Bleed area floor drain			
Blood conveyor blood drain			
Blood conveyor wash drain			
Dehair floor drain			
Scald tank			
Rosin stripper drain	1-31	4	2-2
[illegible] Polisher Drain	2-3	18	2-6
[illegible] Grease drain	1-28	3	1-31
Carcass shower			
Cooler grease drain	1-30 / 2-4	14 / 6	2-5
[illegible] Grease drain	1-31	10	2-3
Head washer drain	2-4	3	2-7
[illegible] washer drain			
Neck washer			

In addition to having the data stored as a card deck, a printed display in matrix form was always prepared. This matrix was identified with all details of time and location. These printouts were used to convey data, and this matrix format was the basis for subsequent data analyses. (See Table E-1)

III PRODUCTION SHIFT DATA ANALYSIS

Data analysis consisted of three steps: (1) statistical analysis, (2) calculating pollution loads, and (3) correlation analysis with graphical output.

Statistical analysis was used to summarize the concentration data available at each sampling point. This was used to facilitate interpretation and, later, to calculate pollution loads. The average concentration of each pollutant at each sampling point for each day is calculated. A sample of the output is shown as Table E-1. The "grand mean" represents the arithmetic average and is considered the best estimate of the average concentration. The "90% maximum value" for each parameter and the standard deviation indicate the spread and variability of the data. Sample points with a large standard deviation have to be sampled more frequently than others to obtain a precise estimate of the average.

The total pollution load calculation was discussed in Section 5 and no lengthy comment is required here. In nearly all cases (days and stations) the best estimate of the mass load of a pollutant was the average concentration multiplied by the average flow rate. This calculation was performed by the computer and the printout is shown in Table E-2. Because of flow measurement problems at some stations, there was not always an estimate of the flow for the day on which samples were collected. Samples were collected on several days at each station to minimize day to day variation that would invalidate this approach. At a few stations the flow and wastewater load was influenced by the start-up of a second kill line. At a few stations the rate of killing (hogs per hour) seemed to change concentrations. Day to day and within day variations were studied to select the proper means of calculating the mass loads. The stations where killing rate made it proper to adjust the calculations were the Hasher Washer Drain and the Hair Wash Drain.

The method of calculation used in these cases is given below.

Calculate gallons/1000 lbLWK (from the daily flows and the corresponding live weight kills.

TABLE E-1

[illegible] PLANT – PRODUCTION

[illegible]

CONCENTRATIONS IN [illegible] PER LITER

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10.0	942.0	594.0	128.0	127.0	0.0	62.4	0.0	0.0	0.0	0.0	0.0	[illegible]	255.0	280.0	254.0	56.
10.5	980.0	530.0	132.0	101.0	0.0	60.9	0.0	0.0	0.0	0.0	0.0	0.0	187.0	262.0	253.0	57.
11.7	856.0	451.0	94.0	94.0	0.0	50.7	0.0	0.0	0.0	0.0	2.0	0.0	177.0	250.0	211.0	46.
11.3	1094.0	650.0	138.0	115.0	0.0	78.5	0.0	0.0	0.0	0.0	0.0	0.0	225.0	300.0	280.0	66.
10.5	860.0	475.0	186.0	105.0	0.0	57.4	0.0	0.0	0.0	0.0	0.0	0.0	175.0	250.0	230.0	55.
3.0	944.0	551.0	102.0	96.0	0.0	62.4	0.0	0.0	0.0	0.0	0.0	0.0	280.0	285.0	254.0	62.
3.3	820.0	464.0	81.0	82.0	0.0	48.1	0.0	0.0	0.0	0.0	0.0	0.0	150.0	225.0	186.0	48.
2.0	956.5	582.0	231.0	232.0	0.0	94.0	0.0	0.0	0.0	0.0	0.0	0.0	287.0	277.0	258.0	61.
3.0	792.0	480.0	154.0	342.0	0.0	48.8	0.0	0.0	0.0	0.0	0.0	0.0	165.0	61.0	186.5	49.
1.1	880.0	480.0	347.0	228.0	0.0	65.5	0.0	0.0	0.0	0.0	0.0	0.0	177.0	227.0	270.0	51.
3.4	1082.0	672.0	150.0	146.0	0.0	80.2	0.0	0.0	0.0	0.0	0.0	0.0	257.0	225.0	364.0	85.
2.0	452.0	528.0	126.0	122.0	0.0	65.8	0.0	0.0	0.0	0.0	0.0	0.0	233.0	351.0	288.0	58.
2.2	1364.0	840.0	136.0	188.0	0.0	78.9	0.0	0.0	0.0	0.0	0.0	0.0	285.0	233.0	346.0	85.

[illegible]

5.1	925.6	552.6	150.2	134.0	0.0	62.4	0.0	0.0	0.0	0.0	0.0	0.0	220.3	228.6	264.5	60.

90 PERCENT PROBABILITY OF OCCURRENCE = VALUE THAT THE POLLUTANT WILL BE LESS THAN 90 PERCENT OF THE TIME

11.4	1046.2	655.7	167.5	157.9	0.0	77.7	0.0	0.0	0.0	0.0	0.0	0.0	257.8	321.6	339.4	78.

STANDARD DEVIATION

4.6	90.8	80.4	21.3	16.6	0.0	11.9	0.0	0.0	0.0	0.0	0.0	0.0	45.7	64.6	58.5	16.

STANDARD ERROR

1.3	25.2	22.3	5.9	5.2	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	12.7	17.9	16.2	5.

[illegible]

[illegible]

[illegible]

AVERAGE FLOW IN GALLONS PER SHIFT = [illegible]

AVERAGE FLOW IN GALLONS PER [illegible] = [illegible]

AVERAGE FLOW IN LITERS PER [illegible] = [illegible]

AVERAGE FLOW IN LITERS PER SHIFT = [illegible]

[illegible]

AVERAGE POUNDS OF POLLUTANT PER SHIFT

[illegible]

AVERAGE POUNDS OF POLLUTANT PER [illegible]

[illegible]

[illegible]

AVERAGE [illegible] OF POLLUTANT PER SHIFT

[illegible]

.Multiply by pollutant concentration to get lb of pollutant/
  1000 lbLWK
.Convert to international units
  -liter/1000kgLWK
  -kg/1000 kgLWK

Correlation analysis was done simply by specifying which columns of the data matrix should be worked with. For example, the BOD-COD correlation could be done by calling column 16 and column 17 from the matrix and entering them in the correlation subprogram. Samples of the correlation analysis were given in Appendix D. Graphical output was managed in the same way and sample graphs are also included in Appendix D. The entire data analysis technique was centered around the matrix display format. This format gave clear, visual displays of data as it was obtained and it aided in pin-pointing errors and problems.

IV CLEANUP SHIFT DATA ANALYSIS

The data management and analysis for the cleanup shift was complicated by the flow measurement data problem. There is extreme variability in flow during cleanup and most of the pollution load is washed out as a "first flush" at the beginning of the cleanup shift. An accurate estimate of both flow and concentration during the first flush was needed. Cleanup hoses and other intermittent water use devices could not be metered directly so the Lithium dilution method was used. This created the need to handle many more samples for lithium analysis along with samples for COD analysis, etc. The inventory control method described before was used.

The data for flow and concentration was combined into estimates of mass loading as illustrated in Section VI. The computer print out that is the counterpart of the example in Section VI is similar to Tables E-1 and E-2.

V CONCLUSIONS

The costs of organizing the data management and analysis system were amply rewarded. There was always easy access to the data and it was always obvious to the laboratory, terminal operator, and project manager the status of the data. As new data was added, estimates of statistics were updated quickly so the next steps of the sampling program could be planned. Making revised calculations required a minimum of effort. This benefit was highlighted late in the study when the average pounds of hogs killed per day was revised. This revision required a recalculation of the pollution loadings at each sample point for both shifts and for each pollution parameter.

Due to the computerized data analysis system, the entire data file was recalculated in three hours.

A well organized data management system repays the initial investment in its creation with many benefits. The management system described was developed during the early part of this project and was used with great success for more than one year. Experience gained from this will be valuable whenever a large sampling program is undertaken in the future.